STANDARDS DEVELOPMENT BRANCH (MOE)
3693600005205

SUDBURY ENVIRONMENTAL STUDY

SULFUR DIOXIDE, SULFURIC ACID, PARTICULATE AND PARTICLE SIZE DETERMINATIONS AT FALCONBRIDGE SMELTER STACK, AUGUST, 1979.

SES 001/82

FALL 1982

TD
883.7
.O6
O97
1982
MOE

Ministry of the Environment
Ontario

The Honourable
Keith C. Norton, Q.C.,
Minister

Gérard J. M. Raymond
Deputy Minister

SUDBURY ENVIRONMENTAL STUDY

SULFUR DIOXIDE, SULFURIC ACID, PARTICULATE AND PARTICLE SIZE DETERMINATIONS AT FALCONBRIDGE SMELTER STACK, AUGUST, 1979.

SES 001/82

by

V. Ozvacic and J. McDonald
Source Assessment Unit
Emissions Technology and Regulation
Development Section, Air Resources Branch
Ontario Ministry of the Environment
880 Bay Street, 4th Floor
Toronto, Ontario, Canada, M5S 1Z8

October 1982

S.E.S. Coordination Office
Ontario Ministry of Environment
6th Floor, 40 St. Clair Ave. W.
Toronto, Ontario, Canada, M4V 1M2
Project Coordinator: E. Piché

SES 001/82
ISBN 0-7743-7764-X
ARB-TDA 40-80

Copyright Provisions and Restrictions on Copying:

This Ontario Ministry of the Environment work is protected by Crown copyright (unless otherwise indicated), which is held by the Queen's Printer for Ontario. It may be reproduced for non-commercial purposes if credit is given and Crown copyright is acknowledged.

It may not be reproduced, in all or in part, part, for any commercial purpose except under a licence from the Queen's Printer for Ontario.

For information on reproducing Government of Ontario works, please contact Service Ontario Publications at copyright@ontario.ca

TABLE OF CONTENTS

		Page
	List of Tables	i
	List of Figures	ii
	Acknowledgements	iii
01.	Summary	1
02.	Conclusions	3
03.	Recommendations	5
04.	Objectives of Sampling Program	6
05.	Operation of Continuous Monitoring System	7
	05.01 Operation of Sampling Unit - Observations and Sampling Data	7
	05.02 Recommended Revisions to Continuous Monitoring System	9
06.	Particulate and Acid Testing	11
	06.01 Particle Emissions	11
	06.02 Emissions of Trace Elements	14
	06.03 Sulfuric Acid Determination	15
07.	Particle Sizing Determinations	18
08.	Effect of Process Variations on Emissions	21

Appendix One - Summary of MOE and Falconbridge Sampling Data

Appendix Two - MOE Equipment Calibration Data

LIST OF TABLES

		Page
1.	Falconbridge Source Sampling Data Summary	28
2.	Sampling Data and Continuous Monitor Summary	29
3.	Elemental Emission Concentration - Falconbridge Smelter	30
4.	Summary - Falconbridge - Emission Rates	31
5.	Stack Sampling Analysis - Acid Test #1	32
6.	Stack Sampling Analysis - Acid Test #2	33
7.	Stack Sampling Analysis - Particulate Test #1	34
8.	Stack Sampling Analysis - Particulate Test #2	35
9.	Stack Sampling Analysis Falconbridge Particulate #1	36
10.	Stack Sampling Analysis Falconbridge Particulate #2	37
11.	Stack Sampling Analysis Falconbridge Preliminary #2	38
12.	Particle Size Distribution - Test #1	39
13.	Particle Size Distribution - Test #2	40
14.	Particle Size Distribution - Test #3	41
15.	Size Distribution of Individual Species	45
16.	Falconbridge Process Data	46
17.	Acid Filter - Quartz - Background Analyses	47
18.	Particulate Filter - Glass Fiber - Background Analyses	47
19.	Probe Wash Filter - Background Analyses	48
20.	Particulate Sizing Substrates - Glass Fiber - Background	49

LIST OF FIGURES

		Page
1.	Falconbridge Continuous Monitoring System	25
2.	Modified Sampling Train for Determination of Sulfuric Acid Emissions	26
3.	Chimney Dimensions - Falconbridge Smelter Stack	27
4.	Aerodynamic Diameter VS Cumulative Percentage: Particle Size Test #1	42
5.	Aerodynamic Diameter VS Cumulative Percentage: Particle Size Test #2	43
6.	Aerodynamic Diameter VS Cumulative Percentage: Particle Size Test #3	44

ACKNOWLEDGEMENTS

Cooperation and contribution of all Falconbridge personnel involved in this study are gratefully acknowledged.

Contribution from personnel of Inorganic Trace Contaminants Section of the Ministry of the Environment Laboratory Services Branch, where samples were analysed under the direction of Dr. B. Foster, was essential to complete this report.

Efforts by the personnel of the Ministry of the Environment Northeastern regional office in planning and execution of this study are also recognized.

0.1 SUMMARY

As part of the Sudbury Environmental Study Program for 1979, a series of source tests were performed at the smelter stack of Falconbridge Nickel Mines. The test series was designed to determine emissions of sulfur dioxide, sulfuric acid, particulate, selected elements and the particle size distribution at this source.

Sulfur dioxide emissions were determined using a Hartmann and Braun non-dispersive infrared (NDIR) analyzer. Equipment failure in the field limited the amount of SO_2 data collected; what data were available agreed to about 50% with SO_2 emission estimates calculated by Falconbridge personnel using a mass balance technique. Better than this comparison may be desirable and further use of the continuous monitoring system both to verify the quality of this comparison and to generate SO_2 emission information for various process configurations is recommended. Sulfur dioxide emission rates in the vicinity of 340 metric tons per day were determined over several hours. Refinements to the design of the SO_2 monitoring system are presented in the body of the report.

Particulate and acid data were collected by MOE personnel using an EPA Method 5 particulate sampling train fitted with a teflon lined flexible 6 m probe. A cumulative sample was collected at 20 points along one diameter of the chimney cross-section. Multipoint particulate sampling at the other port was impossible without extensive modifications to the sampling platform; Falconbridge personnel took particulate samples at a single point through this second port during MOE particulate testing. Based on three MOE multipoint tests and three single point tests conducted by Falconbridge personnel, the mean particulate emission rate and concentration determined at this source were 27.0 $\pm$ 10.3 grams per second (2.33 $\pm$ .89 MTPD) and 0.202 grams per standard cubic meter. While there is evidence of significant variation in daily particulate emissions these mean values are the best emission estimates currently available for this source.

Particulate emission rates and concentrations derived from two simultaneous Falconbridge single point tests were higher than comparable MOE data. This result suggests that particulate stratification may occur within the chimney; however, the evidence of this phenomenon is not adequate to be considered conclusive since, in addition to the errors inherent in the sampling program, a large segment of the cross sectional area has not been sampled.

The quality of sulfuric acid emission data suffered from inaccuracies in both sampling and analysis. Based on limited information, it appears that the sulfuric acid concentration in the emitted stack gas is at most 20 ppm.

Emission data for selected trace elements were also obtained during the sampling program. Based on MOE multi-point test data, the maximum and minimum emission rates of iron were 4.2 and 1.4 g/s; similarly, copper ranged from 0.49 to 0.20 g/s, nickel from 0.41 to 0.14 g/s, lead from 0.79 to 0.27 g/s and arsenic from 0.47 to 0.06 g/s. One Falconbridge singe point test yielded maximum values for iron, copper and nickel of 7.4, 0.88 and 0.69 g/s, respectively. Data on emissions of manganese, cadmium, zinc, aluminum, calcium, and magnesium are available in the body of the report.

The mass median diameter (MMD) determined by three particle sizing tests varied from 2.2 to 4.0 microns, and the portion of particulate matter with a MMD greater than 10 microns ranged from 15 to 30 percent. These data are somewhat lower than the values determined in sizing tests at the 381 m smelter chimney (Superstack) of International Nickel in Sudbury.* A summary of data collected at the Falconbridge smelter stack is contained in Table 1.

* Report ARB-TDA-58-80, June 1980

02. CONCLUSIONS

In reviewing the 1979 test program at the Falconbridge smelter stack the following conclusions were reached:

1) Data generated by a SO_2 continuous analyzer over short time periods did not always compare well with Falconbridge SO_2 emissions estimated by Falconbridge personnel using both mass balance data and stoichiometric requirements. Depending on the time period, differences ranging from a few % to over 50% were indicated. The maximum SO_2 emission rate derived from the monitoring data was approx. 340 metric tonnes per day, based on a monitoring time of 3½ hours.

2) Based on three multipoint tests conducted by the Ministry of the Environment and three single point tests conducted by Falconbridge personnel, the mean particulate emission rate and concentration determined at this source were 27.0 $\pm$ 10.3 grams/second (2.33 $\pm$ .89 MTPD) and 0.202 grams per standard cubic meter. While the test data illustrate that significant variations in both emission rates and concentrations do occur, the mean values given above are the best emission estimates currently available for this source.

3) During two MOE multipoint particulate tests, Falconbridge personnel operated a particulate sampling train at a single point in a second quadrant. In both cases, particulate emission rates and concentrations derived from the Falconbridge procedure were higher than those obtained from MOE testing. The largest variation between two simultaneous multipoint/single point tests was noted in the concentrations derived from test work performed by MOE and Falconbridge on Sept. 14, 1979. The MOE multipoint procedure resulted in an emission concentration of 0.167 g/std m^3, while the Falconbridge single point procedure yielded a concentration value of 0.267 g/std m^3. This result suggests that there is a good possibility that particulate stratification is occuring within the Falconbridge smelter chimney.

4) The quality of sulfuric acid emission data was not sufficient to allow an exact quantification of acid emissions; however the data do suggest that the acid emission concentration is in the vicinity of 25 ppm (corresponding to emissions of .33 MTPD) or less. This estimate should be confirmed by additional testing.

5) Based on three particle sizing tests at this source, the particle distribution within the sampling plane has a mass median diameter between 2.2 and 4.0 microns. These values are somewhat lower than data collected at the International Nickel smelter stack in 1978, where a mass median diameter ranged from 3 to 6 microns.

6) While it was impossible to accurately estimate the impact of process variations on emissions, process data collected on site were valuable in formulating some broad correlations between process operations and emissions. Further refinements to process data collection have been suggested to Falconbridge for use in any future sampling programs.

03. RECOMMENDATIONS

1) Additional continuous monitoring of sulfur dioxide emissions should be carried out at this source, both to verify the accuracy of Falconbridge mass balance calculations for SO_2 over short time spans and to determine the effect of alterations in the process on the SO_2 emissions. Further specific recommendations for alterations to the monitoring equipment are contained in the body of the report.

2) If a conclusive comparison of the variation in particulate emissions as determined by single and multipoint testing is required, further testing involving two complete traverses of the chimney cross-section should be performed. The data contained in this report suggest that with all process units in operation, the particulate concentration in the stack gases should be at a level which will permit shortening the particulate testing period to 3 hours.

3) While data are adequate to permit a first estimate of sulfuric acid emissions, additional sampling, possibly using other methods, should be carried out at this source.

4) Should further particle size testing be considered at this site, testing should be performed in both quadrants to determine if there is any consistent and significant difference in particle size distribution between these two locations.

5) Before any further testing is undertaken at this site, guidelines for the collection of process data during testing should be reviewed and revised as required. In addition, criteria establishing the minimal process activity level required to proceed with source sampling should be formulated.

04. OBJECTIVES OF SAMPLING PROGRAM

In co-ordinating the 1979 source sampling program at the Falconbridge Metals Smelter stack, the following objectives were set:

1. A system to continuously monitor sulfur dioxide emissions from the smelter stack would be installed and operated on a temporary basis. The Source Assessment Unit was primarily responsible for this segment of the program.

2. The Source Assessment Unit would also characterize the particle size distribution in the stack gas stream using an Andersen cascade impactor.

3. Particulate emission rates and concentrations obtained by sampling at a single point would be compared to similar data from a sampling train operating at 20 points along a single traverse. Falconbridge personnel would be responsible for execution of the single point particulate sampling and the Source Assessment Unit would design and execute the multipoint particulate sampling program.

4. The Source Assessment Unit, the Northeastern Regional Office and the Falconbridge personnel would determine relevant process data and ensure the appropriate collection of same. Falconbridge personnel would compile these process data for submission to the Ministry.

5. The Falconbridge and MOE laboratories would co-operate on the analysis of all samples to whatever extent was feasible; MOE would bear ultimate responsibility for successful completion of the analyses.

05 OPERATION OF CONTINUOUS MONITORING SYSTEM

05.01 - Operation of Unit - Observations and Data

As part of the Falconbridge smelter stack sampling program, a SO_2 analyzer was installed at the base of the smelter chimney to provide a continuous trace of SO_2 concentration in gas sampled at the platform level. A schematic diagram of the original design of the continuous monitoring system is given in Figure 1.

Once the complete system was installed on site, it was necessary to modify the installation. The Hartmann and Braun Non-Dispersive Infrared analyzer is very sensitive to changes in inlet flow pressure and the rotameter used to provide a total sample flowrate measurement was found to cause too great a backpressure at the analyzer. To alleviate the problem temporarily, the rotameter was eliminated from the circuit. Table 2 gives a summary of SO_2 data collected by the NDIR analyzer during the course of the smelter stack sampling program; typical SO_2 concentrations were in the vicinity of 1%.

For a majority of the time, the analyzer could be operated on a scale with a full deflection of 2.0% SO_2. However, on occasions when two convertors were operating, the SO_2 concentration in the sample gas would exceed this level, and it was necessary to adjust the analyzer output to a higher scale. Unfortunately, a consistent calibration value could not be maintained through this output switching and data collected on this higher scale were considered invalid. Thus, determination of the SO_2 concentration over the given time periods resulted in an underestimated value, since the magnitude of SO_2 concentrations under all process conditions was not determined. A maximum of 11% of any one monitoring interval was under off-scale conditions and, if it is assumed that the maximum instantaneous SO_2 concentration was approximately 3%, the resulting error in daily SO_2 emissions is estimated to be less than 10%. This 3% estimate was given by Falconbridge personnel.

A 'background' value mentioned in Table 2 refers to sulfur dioxide emissions when neither of two convertors is on line; this value typically lies around 0.3%. Original chart recorder tracings of SO_2 concentrations are currently stored along with the balance of the Falconbridge data collected by the MOE sampling team at the offices of the Air Resources Branch.

Stack gas temperatures near the gas sampling port were also monitored continuously and varied by as much as 65 Celsius degrees in a typical period shown. Again, much of this variation was due to activity on the convertor aisle, with maximum temperatures in the vicinity of 205°C observed during two convertor operation. Unfortunately, as noted in the data presented in Table 2, the connections to the thermocouple failed and thus stack gas temperature information was available for August 24 and 27, 1979 only.

Also, in the course of operating the analyser system, the Permapure moisture removal unit was damaged. This unit was replaced by a simple ice-chilled impinger containing water, which appeared to operate satisfactorily. Finally, on Sept. 11, the 70 m heated sampling line developed a blockage and operation of the system was discontinued.

In performing periodic maintenance of the sampling system, the presence of a wet violet coloured deposit was noted on the particulate filter housing. In addition, there was evidence of corrosive attack on the inlet, suggesting that during the extended periods between maintenance, stack gas temperatures occasionally may have been low enough to permit formation of an acid aerosol. During this program, stack gas temperatures were monitored on a limited basis - typically 4 to 6 hours per day: thus there are no records of possible variations over a continuous 24 hour period.

MOE have reviewed SO_2 emission data submitted by Falconbridge, based on mass balance data for the same time periods as the continuous monitoring system

was operational. SO_2 emissions obtained from these two techniques differ by a few % to over 50%, depending on the time period. These differences could be traced to errors in mass balance and flow measurements in short time periods and errors in the measurements of high SO_2 levels. The errors due to flow measurements in short time period were minimized by averaging flows measured in several tests in different days and the emissions based on these average flows are probably the best estimates of SO_2 emissions from this stack. Use of the monitoring system could be extended in upcoming years to verify the quality of SO_2 emissions obtained by the two methods and to establish a correlation betwen process variations and SO_2 emissions.

05.02 - Recommended Revisions to Continuous Monitoring System

Generally, the data from this segment of the program suggest that the Hartmann and Braun NDIR instrument can be successfully adapted for use in continuously determining SO_2 emissions from this source. A review of the sampling system suggests that the following modifications would simplify operation of the monitoring equipment while ensuring the collection of quality data.

1. Presuming that the sampling program will be conducted in the summer months, elimination of the Technical Heaters sampling line should be considered. A replacement system, using a primary in-stack particulate filter of coarser pore size, coupled with a second filter unit, maintained at less than 100°C outside the stack to capture sulfuric acid mist, could be used. During this test series, the moisture content of the stack gas was found to be 2% or lower (dewpoint 18.5°C) and during a daylight summer sampling program, a polypropylene line sheathed in a dark coating should be adequate to convey the sampled gas to the base without formation of a condensate. Once at the base, the water vapour present can be removed from the gas prior to analysis.

2. In conjunction with this modification, the instrument package at the base should be modified so that

   a) total sample flow rate data are available

   b) a full scale reading in the vicinity of 4% SO_2 is obtained at the instrument.

   c) temperatures at critical points in the system (i.e. acid filter, base of sample line, and Permapure dryer inlet) are available through a combination rotary switch and L.E.D. display. The practice of obtaining a continuous trace of stack temperature at the sampling inlet should be retained in any future program, and an additional or back-up temperature sensing system should be installed at the site.

06. PARTICULATE AND ACID TESTING

Before discussing the acid and particulate tests separately, a few general comments are in order. For the two acid and two particulate tests completed by MOE and the three single point particulate tests performed by Falconbridge during this program, sampling was reasonably isokinetic, with 80% or better of all readings within ± 10% of the ideal rate. Overall average isokinetic sampling rates were within 3% of the ideal, and, while some improvement should be made in future tests, the isokinetic quality of these data is satisfactory. Sampling data from the MOE and Falconbridge particulate and the MOE acid sampling program at the smelter stack are given in Appendix 1.

06.01 - Particulate Emissions

Since both acid and particulate testing were performed using essentially an EPA Method 5 particulate sampling train (see Fig. 2), both testing procedures yield particulate emission data; the particulate emission rates and concentrations for the four tests are given in Table 1. Note that the calculation of particulate emission data includes only material recovered from the front segment and filter of the sampling train; material found in the impinger segment is not defined as particulate in the Ontario Source Testing Code. Numerous process upsets occurred during Acid Test #1, and emission data from this test are not considered representative of 'normal' operating conditions.

Data from three single point particulate sampling tests conducted by the Falconbridge team through a second sampling port at this source are also included in Table 1. Two of these tests were conducted at the same time as the two MOE multi-point particulate tests: the third was a preliminary test performed independent of any MOE particulate sampling. Figure 3 is a diagram of the smelter stack, indicating the location of the MOE and Falconbridge sampling ports in relation to the inlet duct.

Table 1 also contains emission data determined from the particle sizing tests. These data are not considered of comparable quality to those generated by acid and particulate testing; however, they do fall within the range of values determined during the balance of the testing. The fact that these data are closely grouped suggests that the sizing data are reasonably representative of particle size ranges found at a single sampling point in the smelter stack cross section.

Particulate emissions varied considerably over the four MOE tests. As seen in Tables 3 and 4, emission rates and concentrations determined from the particulate tests were significantly higher than those generated from acid testing. The differences in sampling procedures used in these two types of testing would account for only a very minor segment of this variation.

A review of process data collected over the sampling program suggests that much of the variation in emission data from test to test could be due to alteration in the smelter process. While the collected process data are not comprehensive enough to establish a firm correlation between process activity and emissions, they do indicate that frequent process upsets occurred during Acid Test #1, and, as a result, emission data from this test should be considered unrepresentative.

Data from the comparative single point/multipoint particulate tests performed on Sept. 9 and Sept. 14 show significant variations in particulate emissions determined by the two procedures. In both pairs of tests, the particulate concentration determined from the Falconbridge single point sample was significantly higher (maximum 50%) than that determined by the MOE multipoint procedure. The magnitude of the discrepancy in emission data determined by these two procedures suggests that particulate stratification does occur in the smelter stack.

In comparing the particulate emission rates from these pairs of tests, the effect of the stack gas volumetric flow rate on these data must be noted. In simultaneous testing, the average velocity and related volumetric flow rate determined at a single point by Falconbridge is in all cases lower than that calculated from data collected at 20 points by the MOE testing team. Thus, part of the variation in emission rates between simultaneous single and multipoint particulate testing is due to differences in the average stack gas velocity and volumetric flow rate determined from each test procedure.

When determining particulate emissions from both the acid and particulate tests, material caught in the probe was recovered by washing with isopropanol. This isopropanol washing was then filtered and the weight of the filtrate residue determined and added to the filter sample weight. The nature of this filtrate residue was not consistent throughout the test; analytical data from one test suggested the residue was a sulfate, while results of other analysis did not identify a majority of this material. While this material represented less than 5% of the total particulate sample, should similar testing be performed at this source in future, this residue should be subjected to a more rigorous analysis. Analytical data for the acid and particulate tests, as determined by MOE laboratories, can be found in Tables 5, 6, 7 and 8. Similar data for Falconbridge testing are contained in Tables 9, 10 and 11. Background determinations for MOE acid, particulate, particle sizing and front wash filter media are given in Tables 18, 19, 20 and 21.

While it is difficult to determine a single representative emission rate or concentration on the basis of the limited data collected at this source, the mean particulate emission values based on three MOE tests (excluding Acid Test #1) and three Falconbridge single point tests are the best emission estimates currently available for this source. The appropriate values are a particulate emission rate of

27.0 ± 10.3 grams per second (2.33 ± .89 MTPD) and a concentration of 0.202 grams per standard cubic meter. Particulate emission rates determined over the test period ranged from 8.4 grams per second to 37.2 g/s, suggesting that considerable variation in the quantity of particulate emitted from this source from day to day can be anticipated.

06.02 - Emissions of Trace Elements

Table 3 summarizes emission concentrations of 11 elements determined from samples taken by Falconbridge and MOE teams during the 1979 tests. Analytical techniques developed during the INCO sampling programs were applied to the source samples.

Elemental emission data from the single/multipoint comparison tests show, in some instances, significantly broader deviations than do similar particulate data. In the comparison test of Sept. 9, concentration values for copper, iron, cadmium, nickel and calcium derived from the Falconbridge testing were at least a factor of 2 greater than those determined by MOE. Conversely, the MOE value for arsenic testing on this date was a factor of 4 higher than the comparable Falconbridge value.

Elemental emission concentration values were much more comparable in the Sept. 14 test work; most of the Falconbridge values were slightly higher than those determined by MOE, with the exception of aluminum, magnesium, and again arsenic, where MOE values were at least a factor of 6 greater. Table 3 also includes data on the percentage of total particulate accounted for by the elemental analysis; as would be anticipated, there is a good deal of variation in this percent- from a low of 9% to a high of 40%. Much of the spread in these data could be due to process variations; however, sampling and analytical errors may be responsible for some of the scatter as well. The elemental percentage of particulate from Falconbridge preliminary Test #2 was not reported because the arsenic

determination was not considered accurate or representative.

As would be anticipated at this source, iron, nickel copper, lead and magnesium were relatively abundant in the analysed samples. Arsenic data were somewhat scattered; the concentration value of 76 mg/DSCM determined from Falconbridge preliminary test #2 is not considered representative because of nonrigorous testing procedures. The purpose of this test was to provide samples to verify analytical procedures at both Falconbridge and MOE laboratories; since, in addition, none of the other tests resulted in arsenic emissions of this magnitude, this arsenic emission result was judged to be unrepresentative.

Table 4 summarizes emission rates of individual components, calculated based on the analytical data given in Tables 5, 6, 7 and 8. Falconbridge trace metal emission data are also given for the 11 metals.

Iron is the major metallic element among the eleven determined, with emission rates in excess of 1 gram per second during all tests except the final sizing determination. All other elemental emission rates were under 1 g/s; however, the mean emission rates for lead, aluminum, and arsenic were in excess of copper and nickel values. The high aluminum emission concentration and rate data may be due to high and variable filter 'blank' values, since most of the aluminum is found in the acid extraction of the filter, as shown in Tables 5 through 8.

06.03 - Sulfuric Acid Determination

Both particulate and acid testing were performed using what was essentially an EPA method 5 particulate sampling train. In order to quantify sulfuric acid emissions, this train was modified by replacing the glass fibre particulate filter with a quartz medium, using spectro-grade isopropanol as an impinger absorption solution and placing a second quartz filter between the second and third impingers. The sampling train configuration is shown in Figure 2.

Table 4 also includes emission rate data on total sulfates for all tests and isopropanol soluble sulfates for acid tests #1 and #2. The isopropanol fraction is considered to be sulfuric acid; however, the emission rates for this material are equivalent to a concentration of less than 2 ppm as sulfuric acid. Indeed, if the total sulfate value detected during any one acid test is considered to be all sulfuric acid, the emission concentration is less than 20 ppm. Similar testing at the INCO 381 m smelter chimney resulted in acid concentrations of 12 to 28 ppm. It has been estimated that sulfuric acid could constitute approximately 1% of the sulfur dioxide emissions at non-ferrous smelters; if this guideline is applied at the Falconbridge source, it would result in a minimum acid concentration of 25 ppm.

A discrepancy is evident in the analytical data given in Tables 5, 6, and 8. In these data, the IPA filtrate of the front wash contains a significant amount of material which is not identified as sulfate. For example, in Table 5, the residue of this filtered IPA washing after evaporation is given as 33 mg; however, the sulfate content of this filtered washing is given as 4.6 mg and the difference, if taken as sulfate, would account for 30% of the sulfate detected. Only the analytical data from Particulate Test #1 (Table 7) show equivalent amounts of sulfate and residual material. A suitable analytical technique designed to determine the nature of this residual material such as emission spectroscopy could be employed in future testing.

As illustrated in Figure 2, an additional quartz filter was placed between the second and third impinger in the acid sampling train to catch any acid aerosol carried over from the isopropanol absorbing solutions. Sulfate data for this filter are listed under 'impinger filter' in Tables 5 and 6. As can be seen in these tables, total sulfate found on these filters was significant (47 mg and 167 mg); however, an isopropanol extraction of this substrate was not performed and thus this sulfate cannot be conclusively identified as sulfuric acid.

Determination of sulfuric acid values at this site was complicated by the large variation in stack temperatures. Temperatures as low as 105°C were recorded during testing at this source and moist particulate deposits were found both on the continuous monitor sampling inlet which was suspended in the chimney, and on the flexible MOE particulate sampling probe. These observations indicate that condensation of sulfuric acid within the chimney is undoubtedly occurring on occasion at this source.

Application of the current isopropanol absorption procedure for determination of sulfuric acid at these non-ferrous smelting operations yields a reasonable first estimate; however, alternative acid sampling procedures should be reviewed once again and a limited number of methods selected for field evaluation and comparison with the current method.

07. PARTICLE SIZING DETERMINATIONS

Gravimetric data from the three particle sizing tests are given in Tables 12, 13 and 14 along with additional data required to determine the particle size distribution.

Sampling data given in Appendix 1 show that acceptable isokinetic sampling rates were maintained during all tests. However, the Andersen unit is designed for operation at a single flow rate, and at this source, the twin criteria of isokinetic sampling and single flow rate operation could not both be met since stack gas velocities varied from 6 to 7.6 m/s at the single test point. Under these circumstances, isokinetic sampling was given priority and sample gas flow rates were adjusted as the stack gas velocity varied. Also, the flow rate through the impaction head was approximately 0.028 ACCM (1ACFM) and it was necessary to determine stage cut-off points by extrapolation of calibration data obtained at lower flow rates up to 0.9 ACFM. A smaller diameter nozzle should be used in any future particle sizing tests at this site to avoid this extrapolation. These deviations from the recommended procedure could result in an error of about 1 micron in the determination of the mass median diameter.

A review of gravimetric data from all three tests shows that loadings on individual substrates were in excess of the 10 mg guideline recommended by the impactor manufacturer; however, the observed adhesive properties of the particles were such that particle bounce or blow-off should be minimal and the validity of the tests unaffected.

The mass median diameter from Test #1, derived from the plot of aerodynamic particle diameter vs cumulative percentage, is given in Figure 4. Similarly, Figures 5 and 6 present data from the second and third sizing tests. The mass median diameters derived in Test #1 and #3 are nearly identical at 4.0 um, as

is the slope of the distribution line. In both cases, approximately 30% of the particles have diameters in excess of 10 microns. Test #2 yielded an aerodynamic mass median diameter of 2.2 microns with only a 15% fraction of the total particles present having an aerodynamic diameter in excess of 10 microns.

The samples collected during sizing Tests #1 and #2 were similar in appearance; a dark red material with fair to good adhesion characteristics. The sample obtained during Test #3 contained more grayish material, particularly in the cyclone. Emission rate data for the three tests, given in Table 4, indicate that a reduction in iron and an increase in sulfate emissions did occur during Test #3 in comparison to data derived from Tests #1 and #2. Total particulate emissions were highest during the third sizing test but, among the elements, only aluminum, calcium, and magnesium were higher than during Tests #1 and #2, as shown in Table 4. A survey of process data collected during these tests might suggest a rationale for these results.

Table 15 gives mass median diameters based on specific elemental content of the particles. On this basis, iron, copper and nickel bearing particles generally had a mass median diameter reasonably close to the particle mass median diameter. Similarly, sulfate bearing particles were quite close to the particle mass median diameter. Some of this sulfate is probably a spurious formation resulting from the interaction of sulfur dioxide and the glass fibre collection substrates. Particles containing significant quantities of lead and zinc, two of the more volatile metals, both have submicron mass median diameters. In addition, unlike the other species, their size distributions are not log-normal.

One set of 9 glass fibre impactor substrates were weighed, sealed and shipped to the test site to serve as 'blanks' in estimating the possible weighing error

in this procedure. These substrates were returned undisturbed to the MOE laboratories and weighed again according to the original procedure. The largest variation between the first and second weighing was 0.3 milligrams; given the typical loadings collected on each stage during testing, this variation was not considered significant and no adjustment was made to the sample weights.

Although, as mentioned in preceeding paragraphs, improvements could be made in the particle sizing procedure used at this site, the data obtained from this testing suggest that the mass median diameter of particles present in this segment of the stack cross-section source is between 2.2 and 4.0 microns. This range of values is close to that obtained at the INCO Copper Cliff Smelter in recent test work*. Also, the total particulate emissions values derived from these sizing tests fall within the range of values obtained during acid and particulate sampling programs, which indirectly confirms their representativeness.

*Report ARB-TDA-58-80, June 1980

08. EFFECT OF PROCESS VARIATIONS ON EMISSIONS

Table 16 summarizes process data made available by Falconbridge personnel along with selected test data for the Sept. 1979 sampling program. Note the absence of information on electrostatic precipitator performance; partial data on precipitator operation were available for one test only. The absence of these data reduces the possibility of establishing a firm correlation between emission data and process parameters.

The first particulate test had the highest particulate emission concentration and also the longest convertor blowing time. This relationship is maintained in the case of Particulate Test #2; the second highest emission corresponds to a period with the second longest blowing time. During Particulate Test #1, the #1 or pyrrhotite roaster was down over 4 hours of the 6 hours sampled, while Particulate Test #2 was performed with both roasters and the electric furnace on line. However, under normal operating conditions, roaster emissions pass through both an electrostatic precipitator and the acid plant scrubbing system. Thus convertor operations would be expected to have a greater impact on emissions of particulate than would roaster operations.

The average stack gas temperature determined from MOE Particulate Test #1 is an anomaly; despite the high convertor aisle activity, this average temperature is the lowest recorded over the entire test program. During the last half hour of this test, a thermocouple malfunction resulted in an artifically low stack temperature reading but even excluding this period, the average stack gas temperature is the lowest of all the tests at 134^{o}C. However, exhaust gases from both the roasters and electric furnace can be diluted with ambient air by means of tramp air ducts; the process data are not comprehensive enough to indicate if dilution occurred during this testing.

The particulate emission data from Acid Test #1 are inconsistent with what would be anticipated from the process data. Process activity was at a minimum; the pyrrhotite roaster was down throughout the test; the #2 roaster was down for 118 of the 180 minute test period; the acid plant was down for an hour; the #2 electric furnace activity was low, as shown by the low slag additions; and the convertor blowing time as a percentage of testing time was also at a minimum. However, the particulate emission concentration from this test was not at a minimum and the average stack gas temperature was at a maximum (163°C). This high temperature was accompanied by a the gas volumetric flow rate which was at a minimum, as shown in Table 2. These apparent anomalies also could be due to adjustments in 'tramp' air inlets during shut down of the various process units. Because of the frequent shutdowns and start-ups of process units during the sampling, emission data from this test are considered unrepresentative.

Acid Test #2, with a level of activity higher than Acid Test #1 in all phases of production, had the lowest particulate emission - approximately half that of Acid Test #1 - and the second lowest average stack gas temperature. While additional information on electrostatic precipitator operation would be useful, if it is assumed that the precipitators were operating at approximately a comparable efficiency, a comparison of data from Acid Test #1 and #2 does support the contention that frequent process interruptions caused unrepresentative emissions.

In reviewing the process and particle sizing data, Sizing Test #2 had the highest convertor blowing time and the smallest mass median diameter (2.2 microns). This result suggests that particles passing from the convertors and through the associated electrostatic precipitator may be significantly smaller than the balance of the particles from the other two sources. However, the data base is too limited to permit formulation of any more definite conclusions at this time.

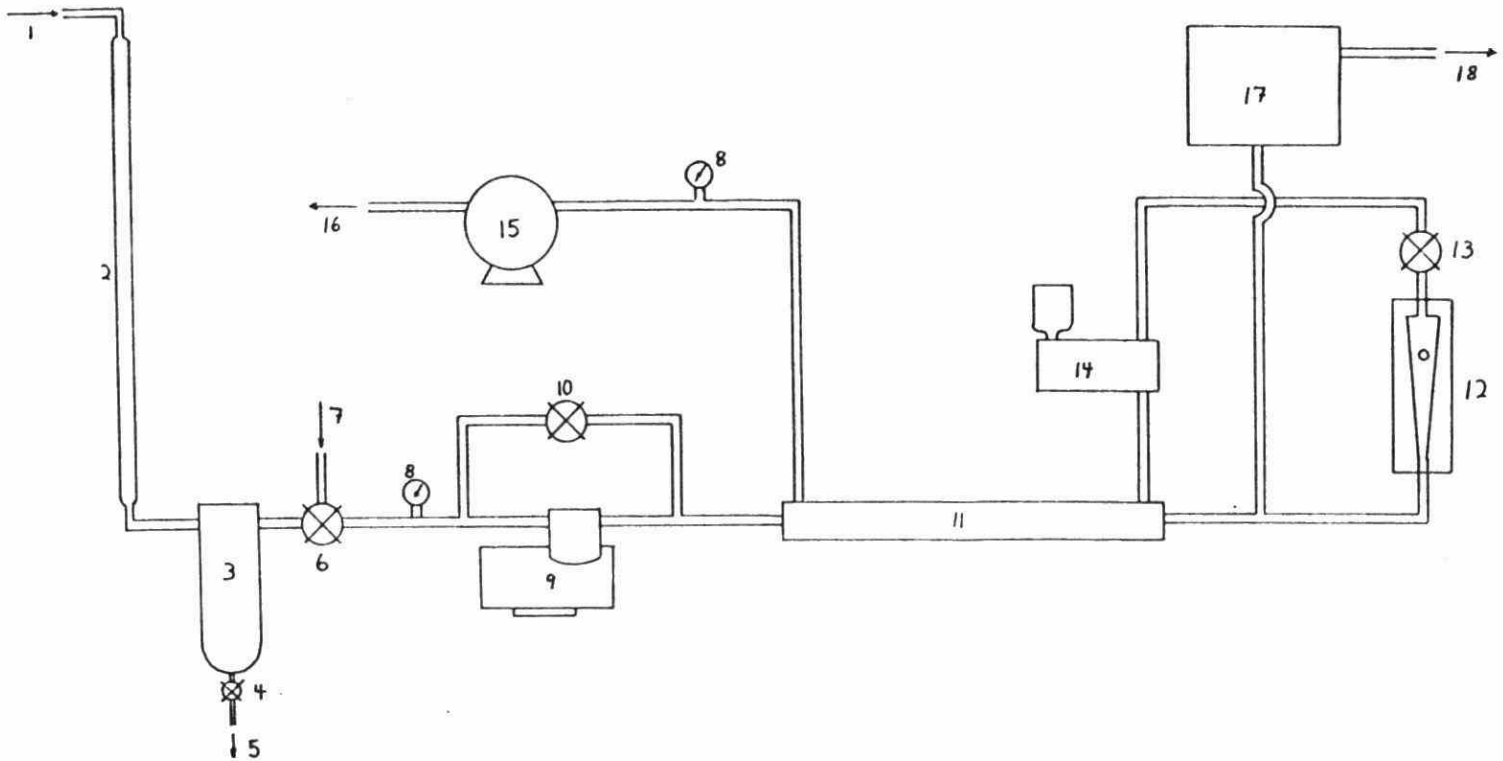
Emission concentrations of individual elements determined during acid and particulate testing are shown in Table 3; a few correlations can be established. Iron, nickel and copper emission concentrations were all at a maximum for Particulate Test #1, as were particulate emissions. As mentioned previously, the #1 roaster was down through almost the entire test, and convertor blowing time was at a maximum, which suggests that, as anticipated, the convertors contribute very signficantly to emissions of these elements, while the roaster impact is slight.

Notwithstanding the minimal process activity during Acid Test #1, emission rates of copper, nickel and iron were second highest during this test. Again, no adequate explanation can be given for these results at this time, other than to note the frequent disruptions in the process.

In reviewing emissions of volatile elements such as lead, cadmium and zinc, Falconbridge personnel were of the opinion that roasting operations do not have a major effect on emissions of these species. Apparently, feed to the pyrrhotite roaster does not contain significant amounts of these elements and in addition the roaster temperatures, typically in the range of 400-510^{o} C, are not adequate to volatilize compounds containing these elements. According to Falconbridge personnel, scrubber liquid from the acid plant is very low in these elements; since under usual operating conditions, all roaster off gases pass through this scrubbing unit, if volatile materials were present in these off gases, a significant portion of them would be found in the scrubber liquid. Rather, Falconbridge personnel suggested that both the electric furnaces and the convertors would be significant sources of volatile elements. Typically, these comparatively volatile elements would be associated with the smaller size fractions.

Little correlation is apparent between arsenic emission concentrations and process data. Arsenic emission concentrations during Acid Test #1 were as high as those from particulate Test #1, even though process activity was at a minimum during the acid test and at a maximum during the particulate test. One of the process units which was inoperative during the acid test was the pyrrhotite roaster; the electric furnace was also idling through the entire test. However, the acid plant was down for 55 minutes during the 3 hour test and SO_2 gases from the #2 roaster were probably fed directly to the stack; this may affect arsenic emission rates.

In conclusion, while the effect on emissions of some macro adjustments in the process was apparent, it is clear that a more thorough study of individual unit operating parameters, including those of the electrostatic precipitators, should be carried out at this source prior to any further testing. This survey should form a basis for determining what parameters should be collected during subsequent source sampling.



1 sample in
2 heated sample line
3 acid trap (Balston 36/12)
4 acid trap drain valve
5 drained acid
6 3 way ball valve (Whitey 44XS6)
7 shut down air
8 vacuum gauge
9 vacuum pump (Thomas 907CA22 TFE)
10 regulating valve (Whitey SS-7RF6)
11 Perma Pure drying tube
12 rotameter (S+K type 20-7050V)
13 shut ball valve (Whitey SS-44S6)
14 make up air manifold
15 vacuum pump
16 vent
17 SO_2 continuous monitor (H&B Uras 2)
18 vent (minimal back pressure)

FIGURE 1: FALCONBRIDGE CONTINUOUS MONITORING SYSTEM

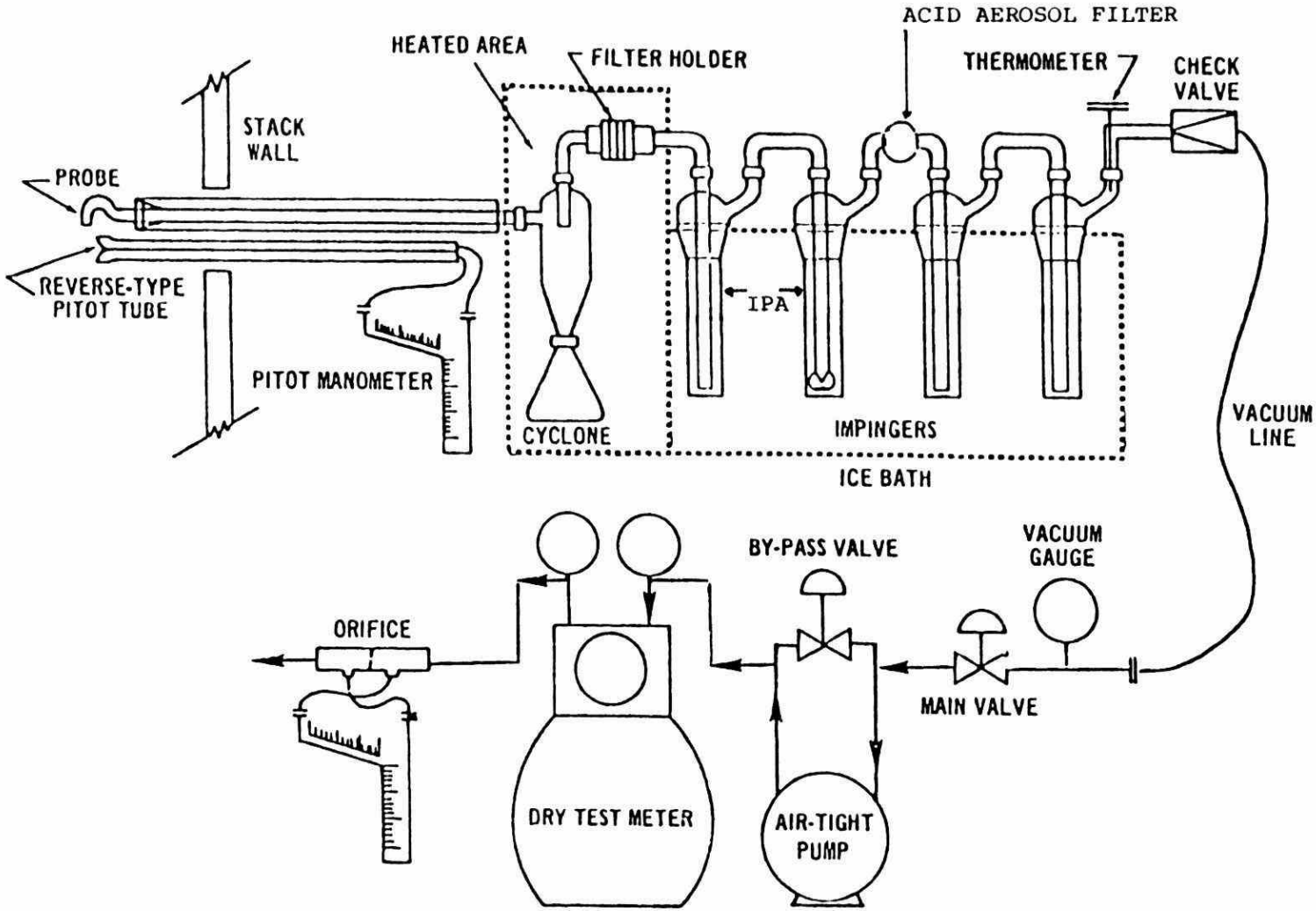
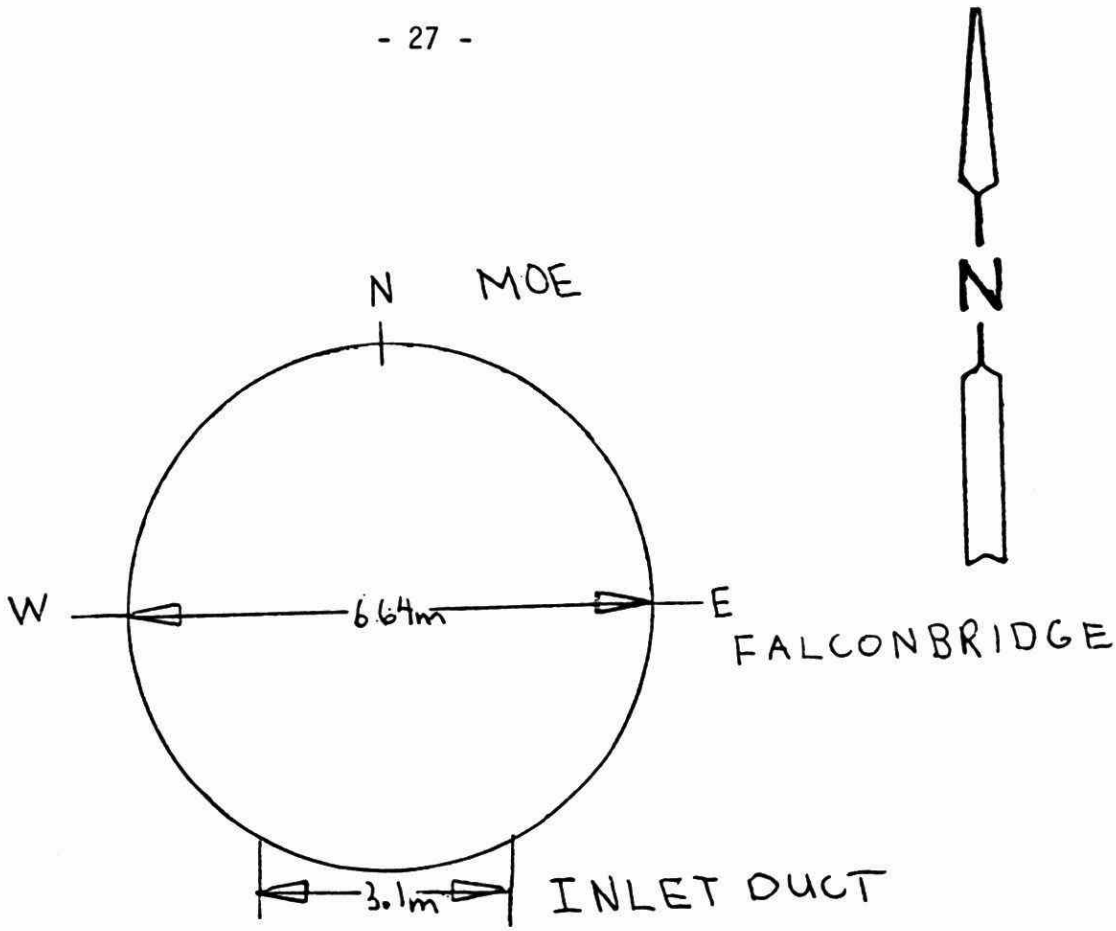


FIGURE 2: MODIFIED SAMPLING TRAIN FOR DETERMINATION OF SULFURIC ACID EMISSIONS



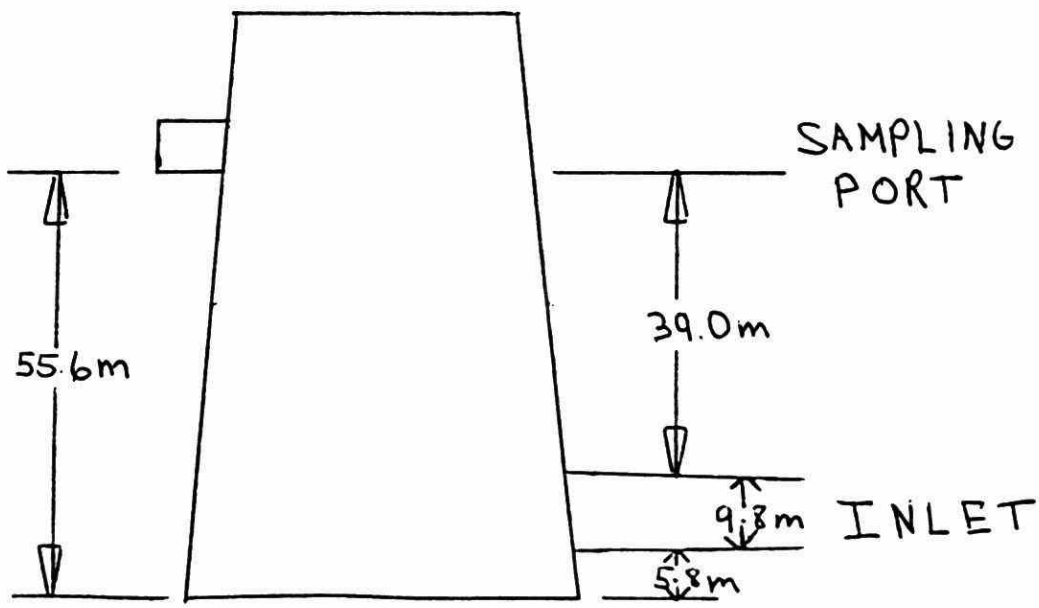


Figure 3: Chimney Dimensions - Falconbridge Smelter Stack

TABLE 1: Falconbridge Source Sampling Data Summary

- September, 1979

Test & Date	%Readings between 100% ± 10% ISO	Particulate Conc. g/std.m^3	Emission Rate g/s	Test Time min	Avg. Temp. °C	Stack Gas Velocity m/s	Stack Gas Flow Rate DSCMM	MMD μm
Part. Size #1 28/8/79	96	.12$^+$	16.7$^+$	92	171	6.4	8520	4.0
Part. Size #2 29/8/79	87	.11$^+$	17.5$^+$	92	167	7.2	9580	2.2
Part. Size #3 30/8/79	93	.136$^+$	21.7$^+$	60	152	7.0	9569.	4.0
Acid #1^o 7/9/79	87	.110^{*o}	15.4^{*o}	180	162.	6.2	8395	
Acid #2 15/9/79	95	.052*	8.5*	180	136.	6.9	9824	
Part.#1 9/9/79	85	.224*	31.8*	303	128.	5.7	8473	
Falconbridge #1 9/9/79	87	.307*	37.2*	360	151.	5.3	7271	
Part.#2 14/9/79	90	.167*	24.0*	300	138.	6.0	8441	
Falconbridge #2 14/9/79	89	.267*	34.0*	300	156	5.7	7629	
Falconbridge Prelim 27/8/79	79	.196*	26.3*	219	191.	6.5	8062	

Particulate Emissions
Mean - 27.0 g/s (2.33 MTPD)
Max. 3.21 MTPD, Min. .72 MTPD
St'd Deviation .89 MTPD

+ Inserted for comparison purposes only.
* Impinger catch not included
o data considered unrepresentative due to process upsets

TABLE 2: Sampling Data and Continuous Monitor Summary
- Falconbridge Sampling Program - September, 1979

FALCONBRIDGE - MOE TEST DATES - SEPTEMBER 1979 PROGRAM

P.S.T. #1	28/8/79 - 92 min 15:30 - 17:00 hr	
P.S.T. #2	29/8/79 - 92 min 11:23 - 12:53	
P.S.T. #3	30/8/79 - 60 min 8:20 - 9:20	
Part #1	9/9/79 - 303 min 10:00-16:00 Aug SO_2 - 1.06%	Falc. Testing Also
Part #2	14/9/79 - 300 min 9:20 - 14:20	Falc. Testing Also
Acid #1	7/9/79 - 180 min 10:30 - 13:30	
Acid #2	15/9/79 - 180 min 8:45 - 11:45	

Continuous SO_2 Analyzer Data

Date	Total Time of Operation Min.	Total Time Analyzer Off Scale Min.	Average Stack Temperature °C	Average SO_2 Conc.° %	Approx. Emissions Rate MTPD	Background SO_2 Conc. %
24/8/79	11:30-16:00 270 min	17	162	.914	285	.3
27/8/79	10:30-16:30 360 min.	39	183*	1.07	340	.25
9/9/79	9:52-16:52	25	N/A	1.06	340	N/A

* Pyrometer failure after 5½ hours.
o Underestimate-does not account for analyzer off-scale periods
N/A Not available

TABLE 3: ELEMENTAL EMISSION CONCENTRATIONS
FALCONBRIDGE - SMELTER
SEPTEMBER 1979

Test and Date	Elemental Concentration - mg/std m^3												
	Mn	Cd	Cu	Fe	Ni	Pb	Zn	Al	Ca	Mg	As	Particulate	% Particulate as Element
ACID #1+ 7/9/79	.037	.35	2.07	17.5	1.72	1.91	.75	3.24	.71	.58	3.39	110.1	29
ACID #2 15/9/79	.02	.35	1.30	10.14	.94	2.67	.91	3.19	.50	.51	.48	51.9	40
PART #1 9/9/79	.04	.27	3.44	29.6	2.88	2.33	.61	.47	.68	1.31	3.30	224.7	20
*Falconbridge #1 9/9/79	.062	.79	7.26	60.9	5.7	2.6	.79	.89	1.94	1.52	.72	285.4	29
PART #2 14/9/79	.02	.53	1.42	9.77	1.03	5.65	.61	4.36	.63	2.34	2.43	167.4	17.2
*Falconbridge #2 14/9/79	.01	.88	2.30	11.0	1.23	4.59	.46	.26	.668	.36	.381	249.7	8.9
o *Falconbridge 27/8/79 Prelim.	-	.2	1.38	20.6	1.63	.62	.27	.32	.14	.14	76.0°	205.	

*Single Point Testing
o analysis suspect
+considered unrepresentative due to process upsets during testing

TABLE 4: SUMMARY - FALCONBRIDGE - EMISSION RATE g/s

	Mn	Cd	Cu	Fe	Ni	Pb	Zn	Al	Ca	Mg	As	Total Part.	Total SO_4	IPA SO_4
Part #1	.006	.04	.49	4.19	.41	.33	.09	.07	.10	.19	.47	31.8	7.76	
Fal. #1 *	.007	.10	.88	7.37	.69	.32	.10	.11	.24	.18	.09	34.5	7.94	
Part #2	.002	.074	.20	1.37	.14	.79	.09	.61	.09	.25	.34	24.0	4.32	
Fal. #2 *	.001	.11	.29	1.41	.16	.59	.06	.03	.09	.05	.05	31.8	7.11	
Acid #1 o	.005	.05	.29	2.45	.24	.27	.11	.45	.10	.08	.47	15.4	5.99	.94
Acid #2	.003	.058	.21	1.66	.15	.44	.15	.52	.08	.08	.08	8.5	13.21	.84
Fal.Prel. *	-	.03	.08	2.74	.22	.08	.04	.04	.02	.02	**9.6**	28.4	34.6+	
The following values are included for comparative purposes only														
P.S.T. #1	.002	.0512	.194	1.30	.127	.293	.067	.340	.203	.098	.06	16.7	4.6	
P.S.T. #2	.002	.017	.227	1.4	.15	.39	.088	.373	.166	.062	.034	17.5	4.5	
P.S.T. #3	.001	.01	.085	.73	.06	.10	.025	.849	.87	.34	.041	21.7	5.1	

+ analysis suspect * emission rates dependent on flow rates - see variation in Table #2
o test not considered representative due to process upsets during sampling.

TABLE 5: STACK SAMPLING ANALYSIS
Falconbridge Smelter Source Testing - 1979
mg/sample

TEST ACID #1

	Metals										Particulate Residual Wt	
1. FRONT CATCH	Mn	Cd	Cu	Fe	Ni	Pb	Zn	Al	Ca	Mg	As	mg	mg SO_4
a) IPA Filtrate	.01	.04	.23	2.1	.25	.07	.32	.1	.08	.14	.91	33	4.6
b) Probe washings-filter													
i) H_2O extract	.04	.09	1.5	2.3	.76	.78	.34	.12	.53	.27	N.D	99	22
ii) Acid extract	N.D	N.D	.95	21	1.65	.33	.06	.30	.18	.17	N.D		
2. FILTER (Quartz)												108	
IPA Extract	N.D	.03	.06	2.27	.05	.02	.12	.01	.05	.05	4.47		4
H_2O Extract	.01	.29	.66	1.1	.26	.37	.33	.05	.3	.24	.11		8.6
Acid Extract	.01	.32	.94	9.0	.74	2.6	.36	6.3	N.D	.29	.02		
3. IMPINGERS													
a) H_2O extract	N.D	N.D	.01	.02	N.D	N.D	N.D	N.D	.01	N.D	N.D	18	N.D
b) Acid extract	N.D	N.D	N.D	.07	N.D	N.D	N.D	N.D	N.D	N.D	N.D		N.D
4. IMP FILTER													
H_2O extract	.01	N.D	.09	.03	.01	N.D	.01	N.D	.04	N.D	N.D		47
Acid Extract	N.D	N.D	N.D	.06	N.D	.01	.01	.14	.07	.02	N.D		
TOTAL mg	.08	.77	4.44	37.95	3.72	4.18	1.55	7.02	1.26	1.18	5.57	240.*	86.2

*imp weight not included

TABLE 6: STACK SAMPLING ANALYSIS
Falconbridge Smelter Source Testing-1979
mg/sample

TEST ACID #2

	Metals												
1. FRONT CATCH	Mn	Cd	Cu	Fe	Ni	Pb	Zn	Al	Ca	Mg	As	Particulate Residual Wt.	$SO_4^=$ mg
a) IPA Filtrate	.01	.03	.20	1.8	.12	.16	.16	.06	.06	.07	0.25	6	2.0
b) Probe Washings-filter													
i) H_2O Extract	.01	.07	.52	.71	.27	.67	.17	N.D	.34	.13	N.D	50	6
ii) Acid Extract	N.D	.01	.62	9.1	.77	.10	.04	.21	.01	.09	N.D		
2. FILTER													
a) IPA extract	N.D	.02	.05	.15	.01	.02	.07	N.D	.04	.03	.68	70	.8
b) H_2O extract	N.D	.13	.19	.33	.07	.29	.08	N.D	.19	.09	.02		3.2
c) Acid extract	.01	.59	1.47	11.9	.99	5.2	.42	7.3	N.D	.44	.01		
3. IMPINGER													
a) H_2O extract	N.D	N.D	.01	.07	.01	N.D	.24	ND	.05	.02	.17		9.6
b) Acid Extract	.01	.01	.03	.45	.03	.03	1.0	.08	.41	.34	.03		6.1
4. IMPINGER FILTER													
H_2O extract	N.D	N.D	.07	.02	.01	N.D	.01	N.D	.04	N.D	N.D		169
Acid extract	N.D	N.D	N.D	.07	N.D	.01	.01	.09	.06	.02	N.D		
TOTAL mg	0.04	.86	3.16	24.6	2.28	6.48	2.2	7.74	1.20	1.23	1.16	126	196.7

TABLE 7: STACK SAMPLING ANALYSIS
Falconbridge Smelter Source Testing - 1979
mg/sample

TEST - Particulate 1	Mn	Cd	Cu	Fe	Ni	Pb	Zn	Al	Ca	Mg	As	Residual wt	SO_4
1. FRONT WASH													
a) IPA Filtrate	.04	.07	.88	8.4	.73	.03	.46	.24	.10	.52	.44	36	36.9
b) Probe Washings-Filter													
i) H_2O extract	.08	.18	6.6	11	3.8	.2	.49	.86	1.54	1.38	.01	383	109
ii) Acid extract	.03.	.01	4.3	92	7.1	2.8	.15	.87	.20	.61	.02		
2. FILTER (sum of 2)													
IPA extract	N.D	.10	.64	7.68	.44	.07	.35	.13	.02	.32	16.4	736	28.9
H_2O extract	.03	.64	2.96	4.3	1.25	1.02	.98	.22	.75	.93	.18		67.1
Acid extract	.03	.36	2.25	28.36	1.42	7.8	.60	N.D	N.D	2.47	.04		
3. IMPINGERS													
IPA soluble	N.D	N.D	.02	.08	N.D	N.D	.06	.02	.13	.02	.03	10*	36.2
IPA insoluble													
i) H_2O extract	N.D	N.D	.01	.04	N.D	N.D	N.D	N.D	.15	N.D	N.D		
ii) Acid extract	N.D	N.D	.01	.04	N.D	N.D	N.D	N.D	N.D	N.D	N.D		
Acid Wash	N.D	.01	.04	.48	.07	.07	.05	.06	.61	.50	.05	6*	3.6
TOTAL mg	.21	1.37	17.72	152.36	14.81	11.99	3.14	2.40	3.50	6.75	17.17	1155	281.7

* impinger residue not included in total

TABLE 8: STACK SAMPLING ANALYSIS
Falconbridge Smelter Source Testing - 1979
mg/sample

TEST - Particulate #2	Mn	Cd	Cu	Fe	Ni	Pb	Zn	Al	Ca	Mg	As	Residual Wt	SO_4
1. FRONT WASH													
a) IPA Filtrate	.01	.12	.35	2.5	.22	.15	.40	.08	.06	.13	.58	25	3.2
b) Probe Washings-Filter													
i) H_2O extract	.02	.20	1.4	1.8	0.8	.7	.4	.08	.47	.24	.01	133	20
ii) Acid extract	N.D	.01	1.1	16.	1.34	1.8	.07	.21	.05	.19	.01		
2. FILTER													
IPA extract	N.D	.09	0.46	1.19	0.36	0.09	.26	.02	.01	.14	7.75	438	10.2
H_2O extract	.01	1.3	1.3	4.2	0.58	0.67	.74	.08	.46	.33	0.06		49.0
Acid Extract	N.D	.15	0.38	8.38	0.31	13.0	.18	15.0	N.D	4.3	0.02		
3. IMPINGERS													
IPA Soluble	N.D	N.D	.01	.1	.01	.01	.08	.01	.49	.25	.19	18*	25.2
IPA insoluble													
i) H_2O extract	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	76*	N.D
ii) Acid extract	N.D	N.D	.01	.09	.01	N.D	N.D	N.D	N.D	N.D	N.D		
Acid Wash	.02	.01	.03	.3	.02	.05	.04	.05	.69	.76	.02	3*	1.7
TOTAL mg	.06	1.88	5.04	34.56	3.65	16.47	2.17	15.53	2.23	6.34	8.64	596*	109.3

* impinger residues not included

TABLE 9:

STACK SAMPLING ANALYSIS
FALCONBRIDGE SOURCE TESTING
FALCONBRIDGE TEAM - 1979 - SINGLE POINT
mg/sample

Test - Falconbridge #1 9/9/79	Mn	Cd	Cu	Fe	Ni	Pb	Zn	Al	Ca	Mg	As	Total Part.	Total $SO_4^=$
1. FRONT WASH													
a) IPA Filtrate	.01	.49	.32	4.50	.31	.63	.13	.18	.04	.34	1.7	32.9	2.9
b) Probe Washings - Filter	.115	2.045	17.1	151.2	17.0	5.1	0.9	2.4	2.3	3.4	.07	578.6	101.1
2. FILTER													
a) IPA Extract	.001	.065	.178	12.	.17	.024	.24	.42	.02	.22	1.82	900.6	31.4
b) H_2O Extract	.11	1.4	13.99	15.	5.0	.45	2.3	1.7	2.96	4.05	.10		146.
c) Residue - Acid	.09	.165	6.75	139.4	7.65	7.49	.53	ND	4.4	ND	.11		
3. IMPINGERS													
a) IPA Extract	.001	.023	.07	.44	.1	.03	.06	.02	.13	.04	.03	4.4	62.8
b) H_2O Extract	ND	ND	.048	.27	.031	.033	.001	.004	ND	.004	ND	49.3	.6
c) Acid Wash	.001	.02	.01	.07	.005	.03	ND	ND	.45	.02	ND	2.8	2.8
TOTAL - mg	.328	4.208	38.47	322.9	30.27	13.79	4.16	4.72	10.3	8.07	3.83	1512.*	347.6

* impinger catch not included

TABLE 10:

STACK SAMPLING ANALYSIS

FALCONBRIDGE SOURCE TESTING

FALCONBRIDGE TEAM - 1979 - SINGLE POINT

mg/sample

Test - Falconbridge #2 14/9/79	Mn	Cd	Cu	Fe	Ni	Pb	Zn	Al	Ca	Mg	As	Total Part.	Total $SO_4^{=}$
1. FRONT WASH													
a) IPA Filtrate	.005	.61	.03	1.5	.18	.16	.12	.07	.06	.11	.245	8.6	25.4
b) Probe Washings - Filter	.014	1.13	2.49	19.8	2.26	3.83	.26	.35	.41	.45	.008	100.6	21.1
2. FILTER													
a) IPA Extract	.004	.339	1.346	3.40	.873	.002	.54	.28	ND	.37	1.28	1063.8	83.7
b) H_2O Extract	.02	1.63	6.18	9.9	1.29	.89	.92	.44	1.27	.61	.084		100.7
c) Residue - Acid	ND	.289	.68	13.2	.44	16.5	.21	ND	.9	.11	.062		ND
3. IMPINGERS													
a) IPA Extract	.009	.13	.05	3.8	.72	.12	.05	.08	.19	.03	.105	10.8	30
b) H_2O Extract	ND	.001	.033	.21	.031	.09	.031	.011	ND	.003	ND	12.8	.7
c) Acid Wash	.001	.008	.01	.08	.009	.01	.02	.01	.31	.02	.003	.5	.7
TOTAL - mg	.053	4.14	10.82	51.89	5.803	21.602	2.151	1.241	3.14	1.703	1.79	1173.*	262.3

* impinger catch not included

TABLE 11: FALCONBRIDGE SOURCE TESTING

FALCONBRIDGE TEAM - 1979 - SINGLE POINT
mg/sample

Prelim. Test
Particulate
Aug. 27, 1979

	Cd	Cu	Fe	Ni	Pb	Zn	Al	Ca	Mg	As	Total* Part	Total SO_4
Front Wash												
. IPA Filtrate	0.10	0.35	1.70	0.13	0.03	0.02	0.02	0.03	0.01	16.6	77	7
. Probe Washings Filter	0.10	.596	1.07	0.238	0.12	0.08	0.05	.14	.14	.34	201.9	30.9
. Final Residue	0.03	3.0	59.08	4.87	1.8	0.17	0.74	-	-	-	-	-
Filter												
. IPA Extract	.165	.17	3.0	0.17	0.06	0.38	0.20	0.08	0.17	250.0	447	1.58
. H_2O	0.22	0.62	0.90	0.20	0.09	0.28	0.09	0.18	0.18	0.095	-	8.2
. Residue-Acid	0.011	0.051	5.87	0.046	0.077	0.007	0.007	N.D.	-	.0	-	-
Impingers												
. IPA Extract	0.07	0.06	0.30	0.07	0.004	0.02	0.02	0.02	0.005	1.74	324	865
. H_2O Extract	N.D.	N.D.	N.D.	.006	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	28.6	3.6
. Acid Wash	0.003	0.03	0.61	0.01	0.001	0.005	0.02	0.05	0.005	0.01	18	
1. Final Residue	0.001	0.02	0.18	0.03	0.005	N.D.	0.01	-	-	-	-	-
TOTAL mg	0.700	4.897	72.71	5.77	2.187	0.962	1.15	0.50	.51	252.65	725.90*	916.28

* Impinger catch not included

TABLE 12: PARTICLE SIZE DISTRIBUTION - TEST #1

Stage	wt (mg)	Cut Point (μm)	%	% <
Nozzle	5.0		2.7	
Inlet	15.6		8.3	
0	12.		6.4	
Cyclone	28.4	8.1	15.2	67.4
1	13.1	6.8	7.0	60.4
2	18.3	4.6	9.8	50.6
3	15.0	3.2	8.0	42.6
4	16.1	1.8	8.6	34.0
5	13.9	.95	7.4	26.6
6	15.4	.62	8.2	18.4
7	15.0	.42	8.0	10.2
Filter	19.1		10.2	0
Total	186.9 mg			

TABLE 13: PARTICLE SIZE DISTRIBUTION - TEST #2

Stage	Wt. (mg)	Cut Point (μm)	%	%<
Nozzle	2.3		1.2	
Inlet	.5		.3	
0	16.0		8.2	
Cyclone	12.9	8.1	6.6	83.7
1	17.6	6.8	9.0	74.7
2	19.5	4.6	10.0	64.7
3	20.1	3.2	10.3	54.4
4	19.6	1.8	10.1	44.3
5	20.9	.95	10.7	33.6
6	21.5	.62	11.0	22.6
7	23.4	.42	12.0	10.6
Filter	20.6		10.6	0
Total	194.9 mg			

TABLE 14: PARTICLE SIZE DISTRIBUTION - TEST #3

Stage	Wt (mg)	Cut Point (um)	%	%
Nozzle	13.2		8.4	
Inlet	17.4		11.1	
0	10.9		7.0	
Cyclone	9.4	8.1	6.0	67.5
1	12.6	6.8	8.1	59.4
2	14.1	4.6	9.0	50.4
3	14.3	3.2	9.1	41.3
4	13.3	1.8	8.5	32.8
5	13.0	.95	8.3	24.5
6	12.1	.62	7.7	16.8
7	10.7	.42	6.8	9.9
Filter	15.4		9.8	0
Total	156.4 mg			

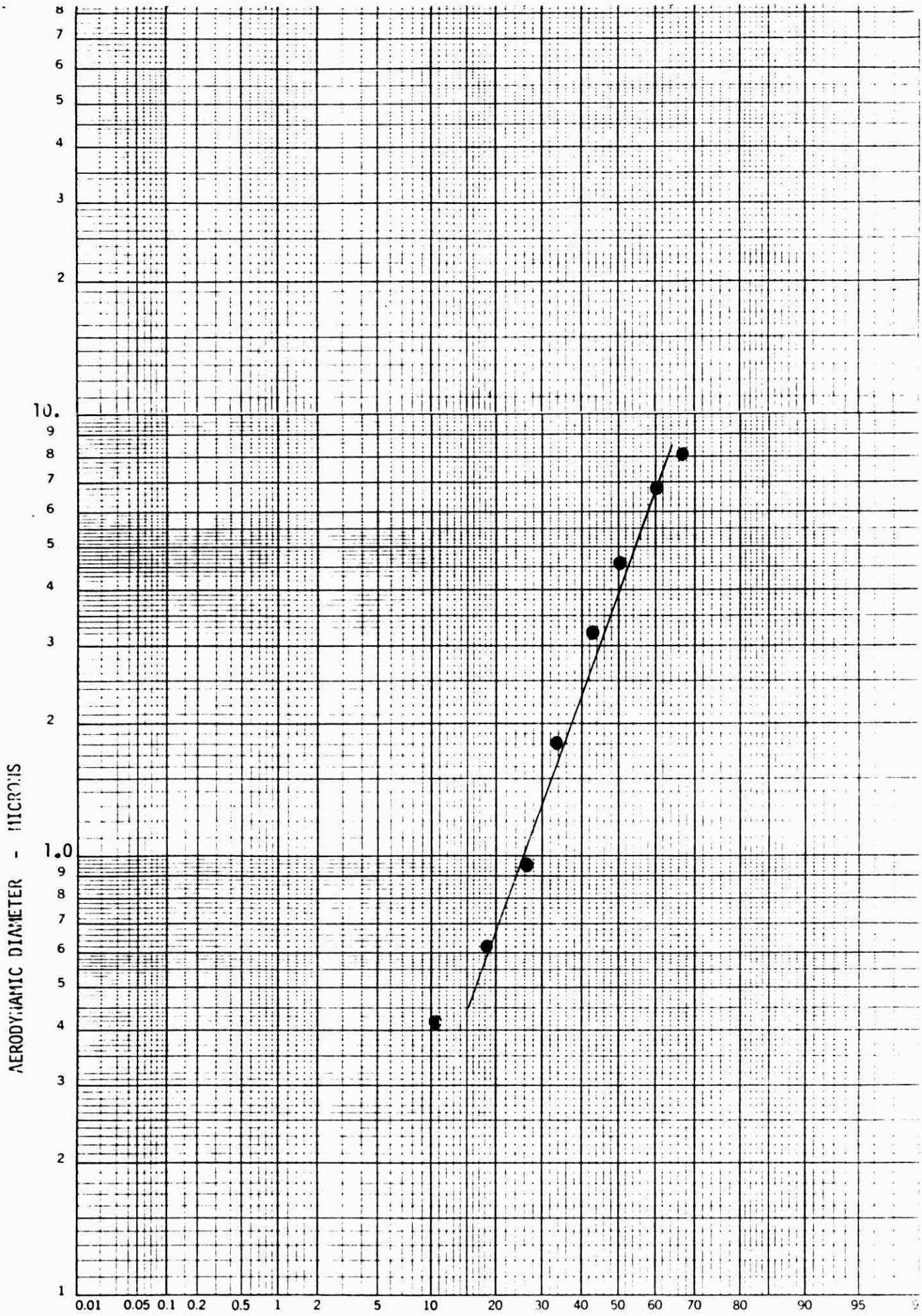


FIGURE 4 CUMULATIVE PERCENTAGE PART. SIZE TEST #1

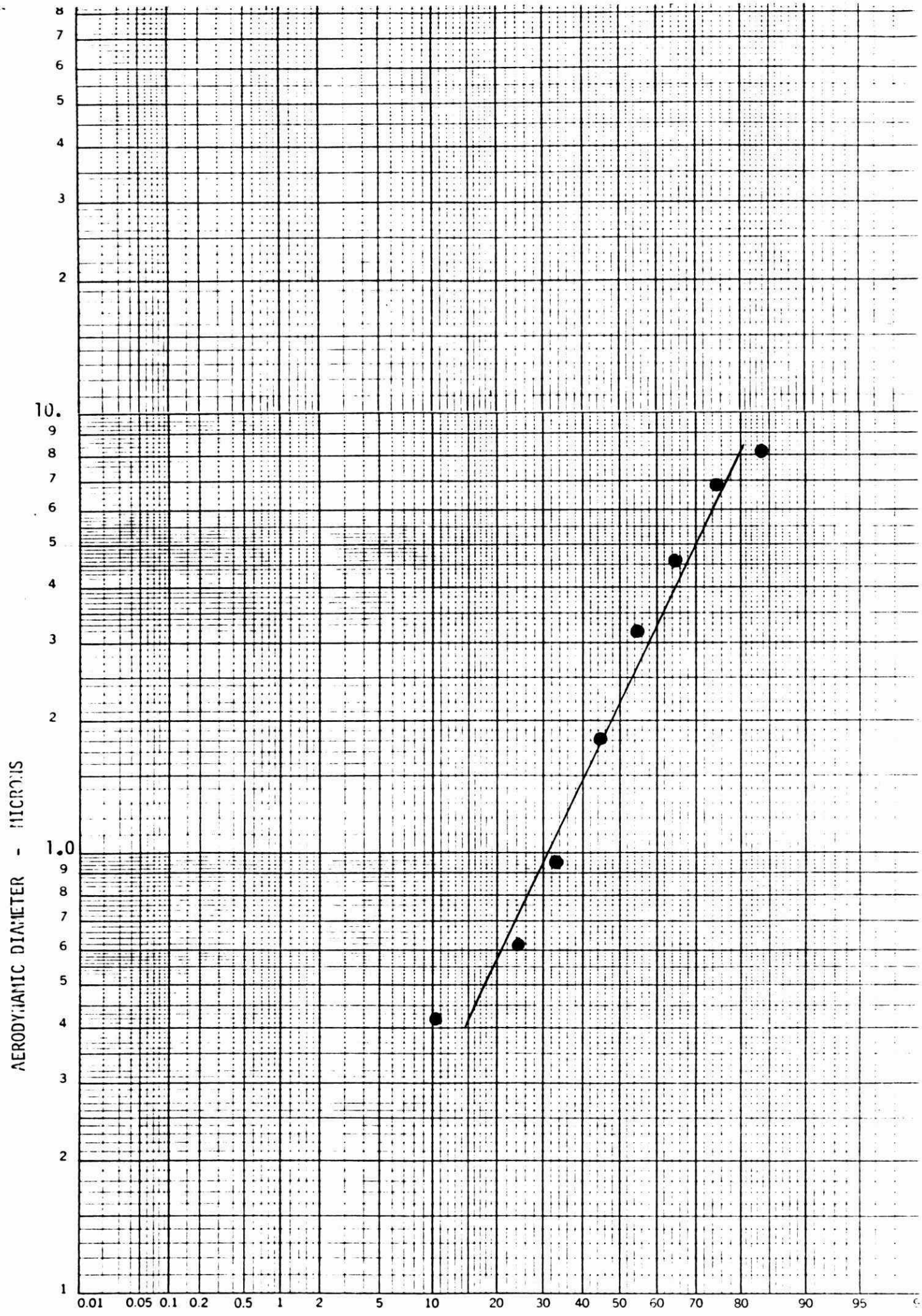


FIGURE 5 CUMULATIVE PERCENTAGE PART. SIZE TEST #2

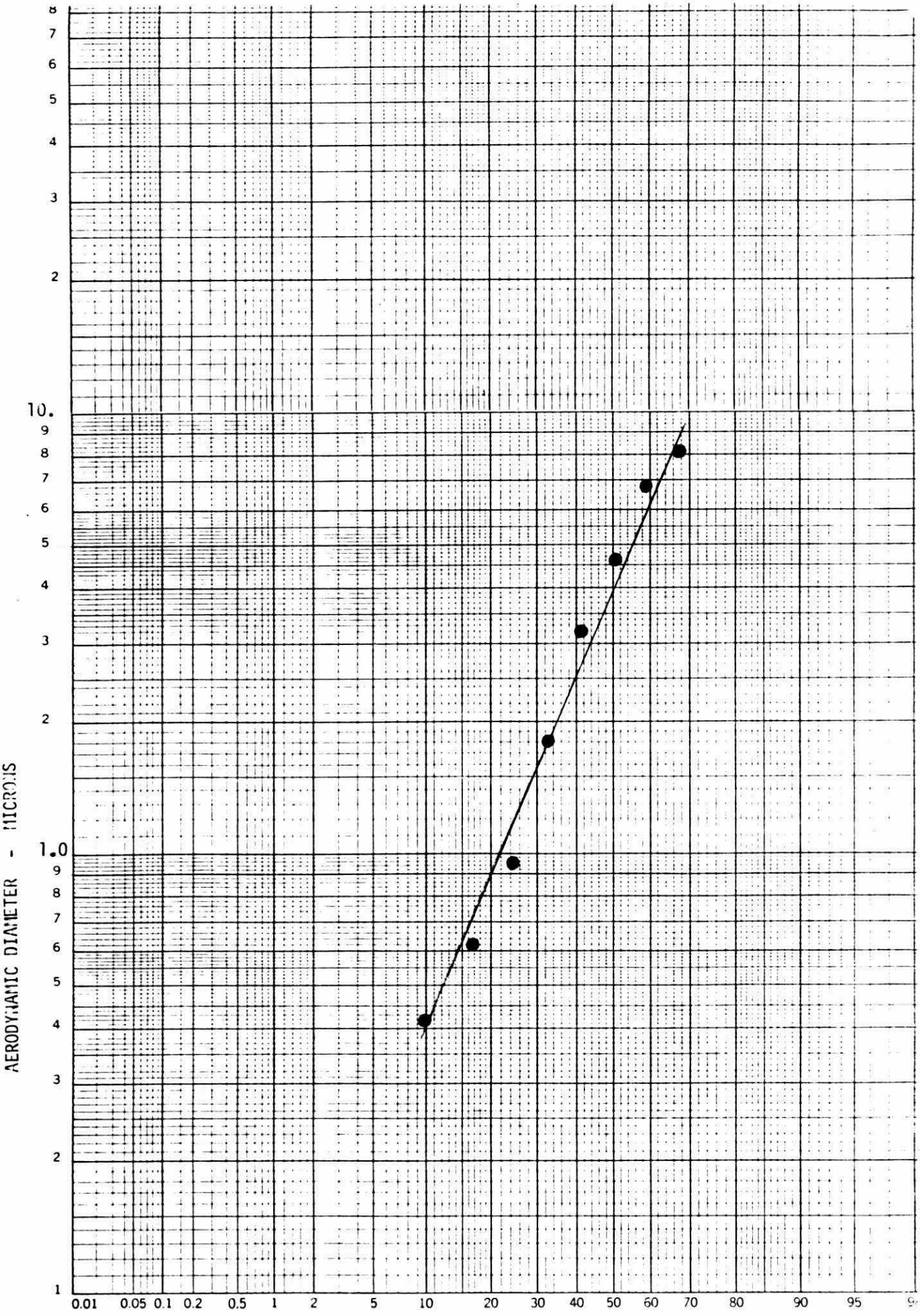


FIGURE 6 CUMULATIVE PERCENTAGE PART. SIZE TEST #3

TABLE 15:

SIZE DISTRIBUTION OF INDIVIDUAL SPECIES

FALCONBRIDGE SMELTER - 1979 SAMPLING PROGRAM

	Species	MMD	Log-Normal Distribution
TEST 1			
Particle Distribution MMD-4.0	Fe	4.6	Yes
	Cu	4.6	Yes
	Ni	5.5	Yes
	$SO_4^{=}$	4.4	Yes
	Pb	< 1.0	No
	Zn	< 1.0	No
TEST 2			
Particle Distribution MMD-2.2	Fe	3.5	Yes
	Cu	3.1	Yes
	Ni	4.0	Yes
	$SO_4^{=}$	2.2	Yes
	Pb	< 1.0	No
	Zn	< 1.0	No
TEST 3			
Particle Distribution MMD-4.0	Fe	7.3	Yes
	Cu	4.7	Yes
	Ni	6.8	Yes
	$SO_4^{=}$	3.5	Yes
	Pb	< 1.0	No
	Zn	< 1.0	No

TABLE 16: FALCONBRIDGE PROCESS DATA

Test	#1 Roaster (Pyrrhotite) Feed tonnes	#1 Roaster (Pyrrhotite) Down	#2 Roaster Feed tonnes	#2 Roaster Down	Acid Plt. Downtime	#2 Electric Furnace Additions tonnes	1 Con. Min's Blowing	2 Conv. Min's Blowing	Stack temp. °C	Particulate Concentrations mg/Std.m^3
Acid #1 7/9/79		entire test		115 m	55 m	15.9 slag 6.0 coke	80	0	163	110.1
Acid #2 15/9/79	136.6		405.8 Feed 105 Flux		-	56. slag 8.5 coke	100	0	136	51.9
Part #1 9/9/79		264 m	421.9 Feed 124.6 Flux		-	48. slag 8.1 slag	165	70	129	224.7
Part #2 14/9/79	160	-	406 Feed 93 Flux		-	52. slag 11.2 coke	150	45	138	167.4
Part Size #1 28/8/79 4.0 um MMD	73.6		367.6 Feed 96.8 Flux		-	54 slag 10.8 coke	70	5	171	
Part Size #2 29/8/79 2.2 um MMD		22 m	398 Feed 110.4 Flux		-	57.6 slag 11.8 coke	58	27	167	
Part Size #3 30/8/79	145.3		404 Feed 116 Flux		-	57.6 slag 10.0 Coke	45	0	152	

ACID TESTS - 3hr; Part 1- 6 hour, Part #2 - 5 hour, P.S.T. 1 and 2 - 92 min., P.S.T.3- 60 min.

ACID FILTER - QUARTZ - BACKGROUND ANALYSIS

TABLE 17: Stack Sampling Analysis - Falconbridge Smelter Stack

	metals ug/sample										mg	µg
	Cd	Cu	Fe	Mn	Ni	Pb	Zn	Al	Ca	Mg	SO_4	As
IPA Extract	0.00	0.002	0.029	0.00	0.001	0.001	0.002	0.00	0.004	<0.002	0.45	0.014
H_2O Extract	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.095	<0.04	1.1	0.001
Acid Extract	0.001	0.006	0.11	0.002	0.002	0.030	0.009	7.95	0.36	0.066	-	<0.001

PARTICULATE FILTER - GLASS FIBER - BACKGROUND ANALYSIS

TABLE 18: Stack Sampling Analysis - Falconbridge Smelter Stack

Description of Sample	metals ug/sample										mg	µg
	Cd	Cu	Fe	Mn	Ni	Pb	Zn	Al	Ca	Mg	SO_4	As
IPA Extract	0.00	0.006	0.014	0.00	0.001	0.00	0.001	0.00	0.006	0.002	0.00	0.016
H_2O Extract	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.245	0.04	0.00	0.00
Acid Extract	0.001	0.002	0.42	0.015	0.004	0.004	0.014	0.84	19.5	4.70	-	0.001

PROBE WASH FILTER - BACKGROUND ANALYSIS

TABLE 19: Stack Sampling Analysis - Falconbridge Smelter Stack

Description of Sample	metals ug/sample										mg	ug
	Cd	Cu	Fe	Mn	Ni	Pb	Zn	Al	Ca	Mg	SO_4	As
Blank #1												
IPA Extract	0.00	0.002	0.004	0.00	0.001	0.001	0.001	0.00	0.007	0.002	1.2	0.001
H_2O Extract	0.00	0.01	0.012	0.00	0.00	0.01	0.00	0.00	0.065	0.04	0.0	0.001
Acid Extract	0.00	0.003	0.64	0.020	0.004	0.008	0.014	24.3	10.6	0.536	-	0.001

(PARTICLE SIZING SUBSTRATES - GLASS FIBER - BACKGROUND ANALYSIS)

TABLE 20 : Stack Sampling Analysis - Falconbridge Smelter Stack

Description of Sample	metals ug/sample										mg	ug
	Cd	Cu	Fe	Mn	Ni	Pb	Zn	Al	Ca	Mg	SO_4	As
Stage 1	ND	0.003	0.183	0.005	0.002	0.022	0.007	4.497	4.647	1.628	1.3	ND
2	ND	0.002	0.221	0.005	0.005	0.001	0.005	4.082	4.266	1.547	3.0	.001
3	ND	0.004	0.18	0.006	0.002	0.001	0.014	4.574	5.252	1.82	1.7	ND
4	ND	0.006	0.21	0.006	0.006	0.008	0.01	5.04	5.5	2.07	1.1	.001
5	ND	0.008	0.222	0.006	0.006	0.007	0.012	5.00	4.88	1.828	1.0	ND
6	ND	0.011	0.252	0.005	0.011	0.008	0.012	3.41	3.735	1.368	1.1	ND
7	ND	0.004	0.191	0.006	0.002	0.006	0.007	5.24	4.793	1.688	1.1	ND
8	ND	0.007	0.211	0.005	0.005	0.006	0.007	4.961	6.355	2.342	1.3	ND
F	ND	0.002	0.20	0.007	0.002	ND	0.008	6.63	6.813	2.421	1.4	ND

APPENDIX 1: MOE and FALCONBRIDGE

SUMMARY OF DATA - INDIVIDUAL SOURCE TESTS

SUMMARY OF EMISSION TESTS

COMPANY: FALCONBRIDGE
LOCATION: SMELTER STACK
CITY: SUDBURY REG.

TEST & DATE: ACID#1,7/9/79
TDA REPORT#: N/A
DATE REPORT REC'D: N/A
CONSULTANT REPORT #:N/A

EMISSION COMPONENT:PARTICULATE (IMPINGER EXCLUDED)

GAS VELOCITY	GAS TEMP.	GAS MOIS.	GAS FLOW	EMISSION RATE	CONCENTRAT.	EMISSION FACTOR
FPS	'F	%	DSCFM	LB/HR	GR/FT3	LB/TONS
20.3	324.6	2.10	2.97E+05	1.224E+02	4.817E-02	1.224E+00
MPS	'C	%	DSCMM	GM/SEC	GM/M3	KG/TONS
6.2	162.6	2.10	8395.19	1.543E+01	1.102E-01	5.554E-01

EMISSION COMPONENT:PARTICULATE (IMPINGERS INCLUDED)

EMISSION RATE	CONCENTRAT.	EMISSION FACTOR
LB/HR	GR/FT3	LB/TONS
1.382E+02	5.439E-02	1.382E+00
GM/SEC	GM/M3	KG/TONS
1.742E+01	1.244E-01	6.271E-01

COMPONENT DISTRIBUTION IN SAMPLING TRAIN

	PROBE	CYCLONE	FILTER	IMPINGERS	TOTAL
PARTICULATE (MG)	132.0000	0.0000	108.0000	31.0000	271.0000
% OF TOTAL PARTICULA	48.7084	0.0000	39.8523	11.4391	100.0000

ISOKINETIC & SAMPLING DATA SUMMARY

AVERAGE %ISOKINETICS	SAMPLING MIN.	SAMPLE VOLUME (SCM)
102.95	180.00	2.18

READINGS	SUB.ISO	SUPERISO	NON.ISO	%WITHIN ISO	ACCEP'LIT. FACTOR	
60	2	6	8	87	90<ISO<110	WELL WITHIN
		ISO	NONISO			
		57	3	95	85<ISO<110	WELL WITHIN

DATA STORED IN FILE1&POS.1/PART
COUNTER H9 STORED IN FILE2= 1.000

SUMMARY OF EMISSION TESTS

COMPANY: FALCONBRIDGE
LOCATION: SMELTER STACK
CITY: SUDBURY REG.

TEST & DATE: ACID#2,15/9/79
TDA REPORT#: N/A
DATE REPORT REC'D: N/A
CONSULTANT REPORT #:N/A

EMISSION COMPONENT:PARTICULATE (IMPINGER EXCLUDED)

GAS VELOCITY	GAS TEMP.	GAS MOIS.	GAS FLOW	EMISSION RATE	CONCENTRAT.	EMISSION FACTOR
FPS	'F	%	DSCFM	LB/HR	GR/FT3	LB/TONS
22.5	276.7	2.03	3.47E+05	6.749E+01	2.269E-02	6.749E-01
MPS	'C	%	DSCMM	GM/SEC	GM/M3	KG/TONS
6.9	136.0	2.03	9823.53	8.504E+00	5.192E-02	3.061E-01

EMISSION COMPONENT:PARTICULATE (IMPINGERS INCLUDED)

EMISSION RATE	CONCENTRAT.	EMISSION FACTOR
LB/HR	GR/FT3	LB/TONS
8.303E+01	2.791E-02	8.30[illegible]E-01
GM/SEC	GM/M3	KG/TONS
1.046E+01	6.387E-02	3.76[illegible]E-01

COMPONENT DISTRIBUTION IN SAMPLING TRAIN

		PROBE	CYCLONE	FILTER	IMPINGERS	TOTAL
PARTICULATE	(MG)	56.0000	0.0000	70.0000	29.[illegible]	155.0000
% OF TOTAL PARTICULA		36.1290	0.0000	45.1612	18.7[illegible]	100.0000

ISOKINETIC & SAMPLING DATA SUMMARY

AVERAGE %ISOKINETICS	SAMPLING MIN.	SAMPLE VOLUME (SCM)
98.22	180.00	2.43

READINGS	SUB.ISO	SUPERISO	NON.ISO	%WITHIN ISO	ACCEP'LITY FACTOR
60	3	0	3	95	90<ISO<110 WELL WITHIN
	ISO	NONISO			
	59	1		98	85<ISO<115 WELL WITHIN

DATA STORED IN FILE1&POS.1/PART
COUNTER H9 STORED IN FILE2= 1.000

SUMMARY OF EMISSION TESTS

COMPANY: FALCONBRIDGE
LOCATION: SMELTER STACK
CITY: SUDBURY REG.

TEST & DATE: PART.#1,9/9/79
TDA REPORT#: N/A
DATE REPORT REC'D: N/A
CONSULTANT REPORT #:N/A

EMISSION COMPONENT:PARTICULATE (IMPINGER EXCLUDED)

GAS VELOCITY	GAS TEMP.	GAS MOIS.	GAS FLOW	EMISSION RATE	CONCENTRAT.	EMISSION FACTOR
FPS	'F	%	DSCFM	LB/HR	GR/FT3	LB/TONS
18.8	263.4	1.60	2.99E+05	2.511E+02	9.788E-02	0.000E+00
MPS	'C	%	DSCMM	GM/SEC	GM/M3	KG/TONS
5.7	128.5	1.60	8473.80	3.164E+01	2.240E-01	0.000E+00

EMISSION COMPONENT:PARTICULATE (IMPINGERS INCLUDED)

EMISSION RATE	CONCENTRAT.	EMISSION FACTOR
LB/HR	GR/FT3	LB/TONS
2.528E+02	9.852E-02	0.000E+00
GM/SEC	GM/M3	KG/TONS
3.185E+01	2.254E-01	0.000E+00

COMPONENT DISTRIBUTION IN SAMPLING TRAIN

		PROBE	CYCLONE	FILTER	IMPINGERS	TOTAL
PARTICULATE	(MG)	414.2000	0.0000	736.2000	7.5000	1157.9000
% OF TOTAL PARTICULA		35.7716	0.0000	63.5806	0.6477	100.0000

ISOKINETIC & SAMPLING DATA SUMMARY

AVERAGE %ISOKINETICS	SAMPLING MIN.	SAMPLE VOLUME (SCM)
99.53	303.00	5.14

READINGS	SUB.ISO	SUPERISO	NON.ISO	%WITHIN ISO	ACCEP'LITY FACTOR
101	7	8	15	85	90<ISO<110 WELL WITHIN
		ISO 92	NONISO 9	91	85<ISO<115 WELL WITHIN

DATA STORED IN FILE1&POS.1/PART
COUNTER H9 STORED IN FILE2= 1.000

SUMMARY OF EMISSION TESTS

COMPANY: FALCONBRIDGE
LOCATION: SMELTER STACK
CITY: SUDBURY REG.

TEST & DATE: PART#2,14/9/79
TDA REPORT#: N/A
DATE REPORT REC'D: N/A
CONSULTANT REPORT #:N/A

EMISSION COMPONENT:PARTICULATE (IMPINGER EXCLUDED)

GAS VELOCITY	GAS TEMP.	GAS MOIS.	GAS FLOW	EMISSION RATE	CONCENTRAT.	EMISSION FACTOR
FPS	'F	%	DSCFM	LB/HR	GR/FT3	LB/TONS
19.6	281.0	1.95	2.98E+05	1.869E+02	7.311E-02	0.000E+00
MPS	'C	%	DSCMM	GM/SEC	GM/M3	KG/TONS
6.0	138.3	1.95	8441.73	2.355E+01	1.673E-01	0.000E+00

EMISSION COMPONENT:PARTICULATE (IMPINGERS INCLUDED)

EMISSION RATE	CONCENTRAT.	EMISSION FACTOR
LB/HR	GR/FT3	LB/TONS
2.163E+02	8.465E-02	0.000E+00
GM/SEC	GM/M3	KG/TONS
2.726E+01	1.937E-01	0.000E+00

COMPONENT DISTRIBUTION IN SAMPLING TRAIN

	PROBE	CYCLONE	FILTER	IMPINGERS	TOTAL
PARTICULATE (MG)	158.0000	0.0000	438.0000	94.0000	690.0000
% OF TOTAL PARTICULA	22.8985	0.0000	63.4782	13.6231	100.0000

ISOKINETIC & SAMPLING DATA SUMMARY

AVERAGE %ISOKINETICS	SAMPLING MIN.	SAMPLE VOLUME (SCM)
100.25	300.00	3.56

READINGS	SUB.ISO	SUPERISO	NON.ISO	%WITHIN ISO	ACCEP'LITY FACTOR
100	4	6	10	90	90<ISO<110 WELL WITHIN
	ISO	NONISO			
	96	4		96	85<ISO<115 WELL WITHIN

DATA STORED IN FILE1&POS.1/PART
COUNTER H9 STORED IN FILE2= 1.000

TEST # FALCONBRIDGE
APPLICABLE TEST METH.
FOR FALCONBRIDGE

TEST TIME: #1 SEPT 9.79
TEST LOCATION: N A FALCONBRIDGE
DATE REPORT PREPARED
CONSULTANT REPORT #:N.A

EMISSION COMPONENT:PARTICULATE (IMPINGER EXCLUDED)

GAS VELOCITY	GAS TEMP.	GAS MOIS.	GAS FLOW	EMISSION RATE	CONCENTRAT.	EMISSION FACTOR
FPS	'F	%	DSCF	LB/HR	GR/FT3	LB/M
17.5	304.2	1.79	2.57E+05	2.954E+02	1.342E-01	8.954E-01
MPS	'C	%	DSCM	GM/SEC	GM/M3	KG/M
5.3	151.2	1.79	7271.	3.722E+01	3.070E-01	1.340E-01

EMISSION COMPONENT:PARTICULATE (IMPINGERS INCLUDED)

EMISSION RATE	CONCENTRAT.	EMISSION FACTOR
LB/HR	GR/FT3	LB/M
3.065E+02	1.392E-01	9.065E-01
GM/SEC	GM/M3	KG/M
3.861E+01	3.185E-01	1.090E-01

COMPONENT DISTRIBUTION IN SAMPLING TRAIN

	PROBE	CYCLONE	FILTER	IMPINGERS	TOTAL
PARTICULATE (MG)	611.5000	0.0000	900.6000	56.5000	1568.6000
% OF TOTAL PARTICULA	38.9838	0.0000	57.4142	3.6019	100.0000

ISOKINETIC : SAMPLING DATA SUMMARY

AVERAGE %ISOKINETICS	SAMPLING MIN.	SAMPLE VOLUME (SCM)
92.54	357.00	4.93

READINGS	SUB.ISO	SUPERISO	NON.ISO	%WITHIN ISO	ACCEP'LITY FACTOR
119	13	2	15	87	90<ISO<110 WELL WITHIN
		ISO	NONISO		
		117	2	98	85<ISO<115 WELL WITHIN

DATA STORED IN FILE1&POS.1/PART
COUNTER #9 STORED IN FILE2= .000

TEST DATE: 2 SEPT. 14 1979
TIA REPORT#: N/A FALCONBRIDGE
DATE REPORT RECD: APRIL 3, 1980
CONSULTANT REPORT #:N/A

EMISSION COMPONENT:PARTICULATE (IMPINGER EXCLUDED)

GAS VELOCITY	GAS TEMP.	GAS MOIS.	GAS FLOW	EMISSION RATE	CONCENTRAT.	EMISSION FACTOR
FPS	'F	%	DSCF	LB/HR	GR/FTS	LB/#
18.7	313.0	1.36	2.70E+05	2.699E+02	1.169E-01	2.699E-01
MPS	'C	%	DSCM	GM/SEC	GM/M3	KG/#
5.7	156.1	1.36	7629.'3	3.401E+01	2.674E-01	1.224E-01

EMISSION COMPONENT:PARTICULATE (IMPINGERS INCLUDED)

EMISSION RATE	CONCENTRAT.	EMISSION FACTOR
LB/HR	GR/FTS	LB/#
2.755E+02	1.193E-01	2.755E-01
GM/SEC	GM/M3	KG/#
3.471E+01	2.729E-01	1.250E-01

COMPONENT DISTRIBUTION IN SAMPLING TRAIN

		PROBE	CYCLONE	FILTER	IMPINGERS	TOTAL
PARTICULATE	(MG)	109.2000	0.0000	1063.8000	24.1000	1197.1000
% OF TOTAL PARTICULA		9.1220	0.0000	88.8647	2.0132	100.0000

ISOKINETIC SAMPLING DATA SUMMARY

AVERAGE %ISOKINETICS	SAMPLING MIN.	SAMPLE VOLUME (SCM)
93.44	300.00	4.39

RADIUS	SUB.ISO	SUPERISO	NON.ISO	%WITHIN ISO	ACCEPTABILITY FACTOR
10	10	1	11	89	90<ISO<110 WELL WITHIN

	ISO	NONISO		
	98	2	98	85<ISO<115 WELL WITHIN

TRAIN FILTER IN AT SUPERISO.1 PART
OF FILTER IN FILTER .000

SUMMARY OF EMISSION TESTS

COMPANY: FALCONBRIDGE
LOCATION: SMELTER STACK
CITY: FALCONBRIDGE

TEST & DATE: PREL. AUG.27/79
TDA REPORT#: FAL-1
DATE REPORT REC'D: MAY 5,1980
CONSULTANT REPORT #:N/A

EMISSION COMPONENT:PARTICULATE (IMPINGER EXCLUDED)

GAS VELOCITY	GAS TEMP.	GAS MOIS.	GAS FLOW	EMISSION RATE	CONCENTRAT.	EMISSION FACTOR
FPS	'F	%	DSCFM	LB/HR	GR/FT3	LB/TONNES
21.4	377.2	1.54	2.85E+05	2.092E+02	8.561E-02	2.092E-01
MPS	'C	%	DSCMM	GM/SEC	GM/M3	KG/TONNES
6.5	191.8	1.54	8069.62	2.635E+01	1.959E-01	9.488E-02

EMISSION COMPONENT:PARTICULATE (IMPINGERS INCLUDED)

EMISSION RATE	CONCENTRAT.	EMISSION FACTOR
LB/HR	GR/FT3	LB/TONNES
2.178E+02	8.914E-02	2.178E-01
GM/SEC	GM/M3	KG/TONNES
2.744E+01	2.039E-01	9.879E-02

COMPONENT DISTRIBUTION IN SAMPLING TRAIN

	PROBE	CYCLONE	FILTER	IMPINGERS	TOTAL
PARTICULATE (MG)	247.2000	0.0000	446.7000	28.6000	722.5000
% OF TOTAL PARTICULA	34.2145	0.0000	61.8269	3.9585	100.0000

ISOKINETIC & SAMPLING DATA SUMMARY

AVERAGE %ISOKINETICS	SAMPLING MIN.	SAMPLE VOLUME (SCM)
97.54	219.00	3.54

READINGS	SUB.ISO	SUPERISO	NON.ISO	%WITHIN ISO	ACCEP'LITY FACTOR
73	0	0	0	100	90<ISO<110 WELL WITHIN
	ISO	NONISO			
	73	0		100	85<ISO<115 WELL WITHIN

DATA STORED IN FILE1&POS.1/PART
COUNTER H9 STORED IN FILE2= 1.000

SUMMARY OF EMISSION TESTS

COMPANY: FALCONBRIDGE
LOCATION: SMELTER STACK
CITY: SUDBURY REG.

TEST & DATE: PART. SZ#1,28/8/79
TDA REPORT#: N/A
DATE REPORT REC'D: N/A
CONSULTANT REPORT #:N/A

EMISSION COMPONENT:PARTICULATE (IMPINGER EXCLUDED)

GAS VELOCITY	GAS TEMP.	GAS MOIS.	GAS FLOW	EMISSION RATE	CONCENTRAT.	EMISSION FACTOR
FPS	'F	%	DSCFM	LB/HR	GR/FT3	LB/TONS
21.0	340.0	2.07	3.01E+05	1.326E+02	5.142E-02	1.326E+00
MPS	'C	%	DSCMM	GM/SEC	GM/M3	KG/TONS
6.4	171.1	2.07	8519.54	1.671E+01	1.176E-01	6.016E-01

EMISSION COMPONENT:PARTICULATE (IMPINGERS INCLUDED)

EMISSION RATE	CONCENTRAT.	EMISSION FACTOR
LB/HR	GR/FT3	LB/TONS
1.326E+02	5.142E-02	1.326E+00
GM/SEC	GM/M3	KG/TONS
1.671E+01	1.176E-01	6.016E-01

COMPONENT DISTRIBUTION IN SAMPLING TRAIN

	PROBE	CYCLONE	FILTER	IMPINGERS	TOTAL
PARTICULATE (MG)	61.0000	0.0000	125.9000	0.0000	186.9000
% OF TOTAL PARTICULA	32.6377	0.0000	67.3622	0.0000	100.0000

ISOKINETIC & SAMPLING DATA SUMMARY

AVERAGE %ISOKINETICS	SAMPLING MIN.	SAMPLE VOLUME (SCM)
101.40	92.00	1.59

READINGS	SUB.ISO	SUPERISO	NON.ISO	%WITHIN ISO	ACCEP'LITY FACTOR
23	0	1	1	96	90<ISO<110 WELL WITHIN
	ISO	NONISO			
	22	1		96	85<ISO<115 WELL WITHIN

DATA STORED IN FILE1&POS.1/PART
COUNTER H9 STORED IN FILE2= 1.000

SUMMARY OF EMISSION TESTS

COMPANY: FALCONBRIDGE
LOCATION: SMELTER STACK
CITY: SUDBURY REG.

TEST & DATE: PART SZ#2,29/8/79
TDA REPORT#: N/A
DATE REPORT REC'D: N/A
CONSULTANT REPORT #:N/A

EMISSION COMPONENT:PARTICULATE (IMPINGER EXCLUDED)

GAS VELOCITY	GAS TEMP.	GAS MOIS.	GAS FLOW	EMISSION RATE	CONCENTRAT.	EMISSION FACTOR
FPS	'F	%	DSCFM	LB/HR	GR/FT3	LB/TONS
23.8	332.0	1.95	3.38E+05	1.387E+02	4.783E-02	1.387E+00
MPS	'C	%	DSCMM	GM/SEC	GM/M3	KG/TONS
7.2	166.6	1.95	9580.17	1.748E+01	1.094E-01	6.294E-01

EMISSION COMPONENT:PARTICULATE (IMPINGERS INCLUDED)

EMISSION RATE	CONCENTRAT.	EMISSION FACTOR
LB/HR	GR/FT3	LB/TONS
1.387E+02	4.783E-02	1.387E+00
GM/SEC	GM/M3	KG/TONS
1.748E+01	1.094E-01	6.294E-01

COMPONENT DISTRIBUTION IN SAMPLING TRAIN

		PROBE	CYCLONE	FILTER	IMPINGERS	TOTAL
PARTICULATE	(MG)	31.7000	0.0000	163.2000	0.0000	194.9000
% OF TOTAL PARTICULA		16.2647	0.0000	83.7352	0.0000	100.0000

ISOKINETIC & SAMPLING DATA SUMMARY

AVERAGE %ISOKINETICS	SAMPLING MIN.	SAMPLE VOLUME (SCM)
100.20	92.00	1.78

READINGS	SUB.ISO	SUPERISO	NON.ISO	%WITHIN ISO	ACCEP'LITY FACTOR	
23	2	1	3	87	90<ISO<110	WELL WITHIN
		ISO	NONISO			
		22	1	96	85<ISO<115	WELL WITHIN

DATA STORED IN FILE1%POS.1/PART
COUNTER H9 STORED IN FILE2= 1.000
COUNTER= 1.000

SUMMARY OF EMISSION TESTS

COMPANY: FALCONBRIDGE
LOCATION: SMELTER STACK
CITY: SUDBURY REG.

TEST & DATE: PART SZ#3 30/8/79
TDA REPORT#: N/A
DATE REPORT REC'D: N/A
CONSULTANT REPORT #:N/A

EMISSION COMPONENT:PARTICULATE (IMPINGER EXCLUDED)

GAS VELOCITY	GAS TEMP.	GAS MOIS.	GAS FLOW	EMISSION RATE	CONCENTRAT.	EMISSION FACTOR
FPS	'F	%	DSCFM	LB/HR	GR/FT3	LB/TONS
23.1	305.7	2.92	3.38E+05	1.720E+02	5.937E-02	1.720E+00
MPS	'C	%	DSCMM	GM/SEC	GM/M3	KG/TONS
7.0	152.1	2.92	9569.43	2.167E+01	1.358E-01	7.803E-01

EMISSION COMPONENT:PARTICULATE (IMPINGERS INCLUDED)

EMISSION RATE	CONCENTRAT.	EMISSION FACTOR
LB/HR	GR/FT3	LB/TONS
1.720E+02	5.937E-02	1.720E+00
GM/SEC	GM/M3	KG/TONS
2.167E+01	1.358E-01	7.803E-01

COMPONENT DISTRIBUTION IN SAMPLING TRAIN

		PROBE	CYCLONE	FILTER	IMPINGERS	TOTAL
PARTICULATE	(MG)	50.9000	0.0000	105.5000	0.0000	156.4000
% OF TOTAL PARTICULA		32.5447	0.0000	67.4552	0.0000	100.0000

ISOKINETIC & SAMPLING DATA SUMMARY

AVERAGE %ISOKINETICS	SAMPLING MIN.	SAMPLE VOLUME (SCM)
99.47	60.00	1.15

READINGS	SUB.ISO	SUPERISO	NON.ISO	%WITHIN ISO	ACCEP'LITY FACTOR
15	1	0	1	93	90<ISO<110 WELL WITHIN
	ISO	NONISO			
	15	0		100	85<ISO<115 WELL WITHIN

DATA STORED IN FILE1&POS.1/PART
COUNTER H9 STORED IN FILE2= 1.000

APPENDIX TWO

MOE PROBE CALIBRATION DATA

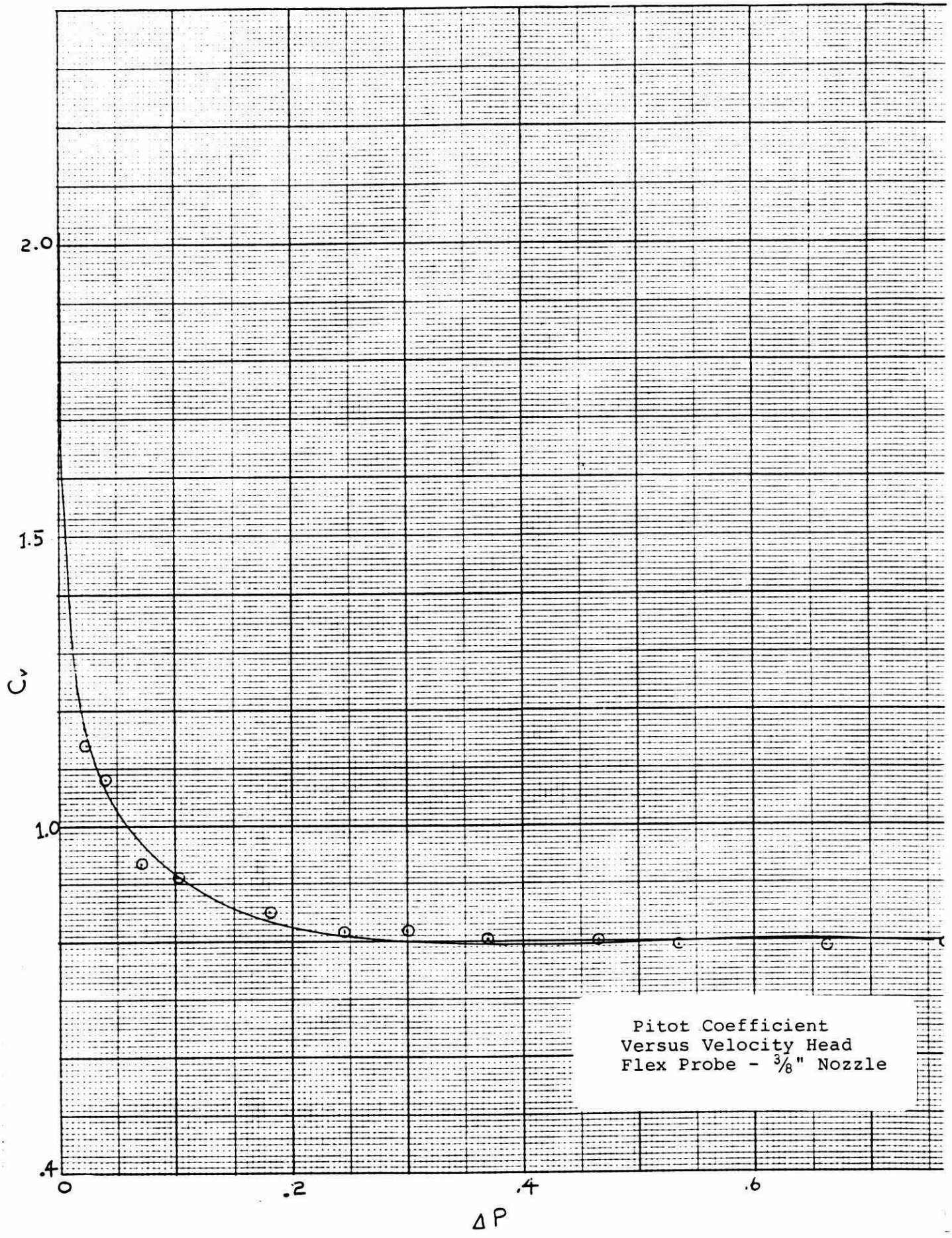
DATE 8/08/79 AMBIENT TEMPERATURE 26°C

INSTRUMENT Flex Probe - 3/8" nozzle REFERENCE STANDARD .99

BAROMETRIC PRESSURE 754.9 mm Hg

(Where necessary, illustrate orientation of probe components on other side of page.)

Wind Tunnel Fan Speed (RPM)	m/s	Temperature Wet	Temperature Dry	Δ P Ref. cm x.2	Δ P Instrument/Velocity Reading cm x.2	inches	C_v
150	3.12	20	24	.3	.05	.004	2.42
250	3.61			.4	.3	.024	1.14
350	4.42			.6	.5	.039	1.08
450	5.10			.8	.9	.071	.933
575	5.98			1.1	1.3	.102	.911
750	7.44			1.7	2.3	.181	.851
875	8.26			2.1	3.1	.244	.815
1000	9.20			2.6	3.8	.299	.819
1075	10.04			3.1	4.7	.370	.804
1200	11.19			3.85	5.9	.465	.800
1300	11.96			4.4	6.8	.535	.796
1400	13.13			5.3	8.4	.661	.790
1500	14.20			6.20	9.7	.764	.791
1600	15.09			7.00	11.0	.866	.796
1700	16.18	20	25	8.05	12.6	.992	.796



Pitot Coefficient
Versus Velocity Head
Flex Probe - 3/8" Nozzle

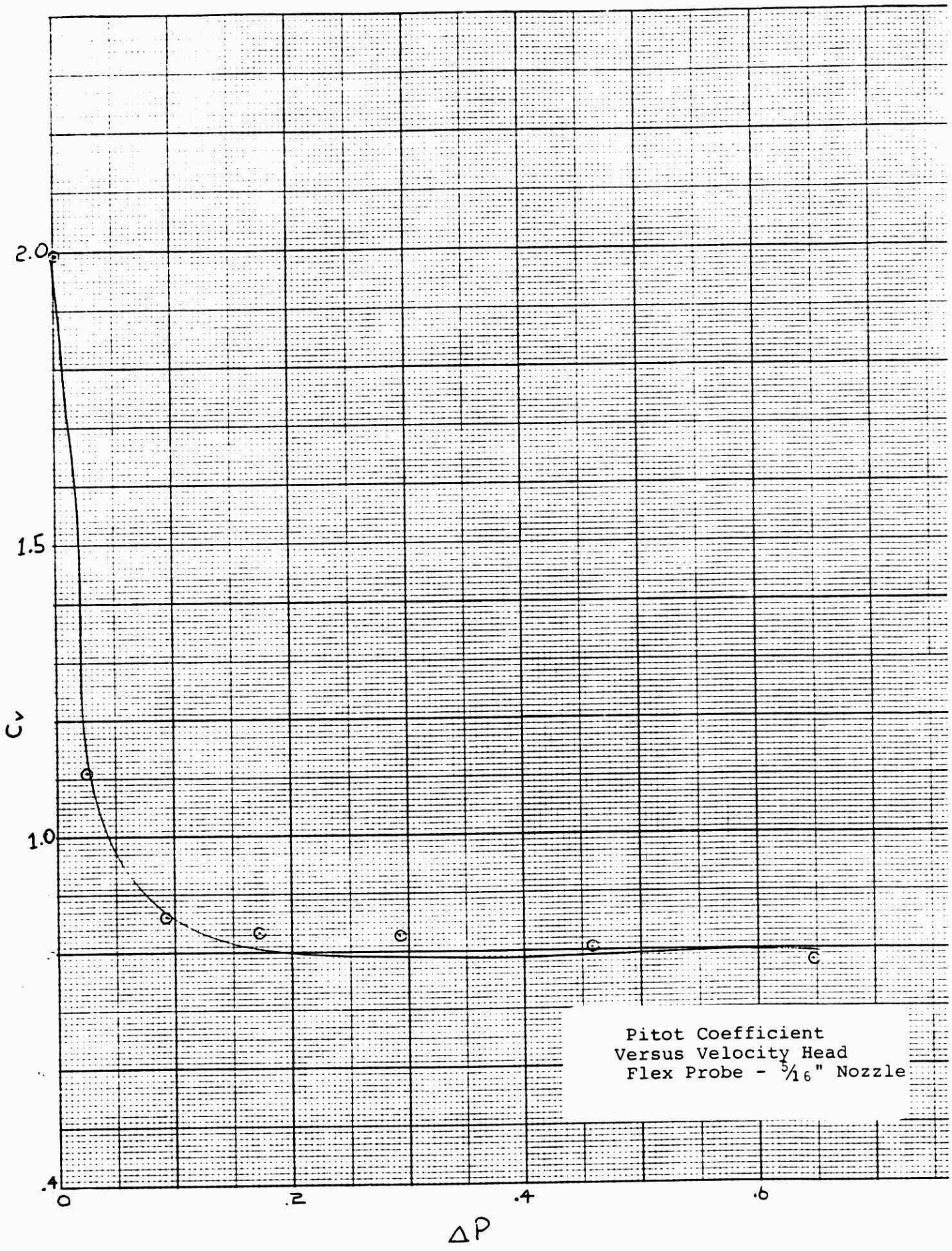
DATE 8/08/79 AMBIENT TEMPERATURE 24°C

INSTRUMENT 5/16" nozzle - Flex probe REFERENCE STANDARD .99

BAROMETRIC PRESSURE 754.9 mm Hg

(Where necessary, illustrate orientation of probe components on other side of page.)

Wind Tunnel Fan Speed (RPM)	m/s	Temperature Wet	Temperature Dry	Δ P Ref. .2 cm	Δ P Instrument/Velocity Reading x.2	inches	C_v
135	2.54	20	24	.2	.05	.0039	1.98
350	4.02			.5	.4	.0315	1.11
550	5.39			.9	1.2	.0945	.857
750	6.96			1.5	2.2	.173	.817
1000	9.00			2.5	3.7	.291	.814
1200	11.1			3.8	5.8	.457	.801
1410	12.9			5.2	8.2	.646	.788
1650	15.5			7.4	11.6	.913	.791
1720	16.2			8.1	12.7	1.00	.791
1720	16.3	21	24	8.2	12.8	1.008	.792



Pitot Coefficient
Versus Velocity Head
Flex Probe - 5/16" Nozzle

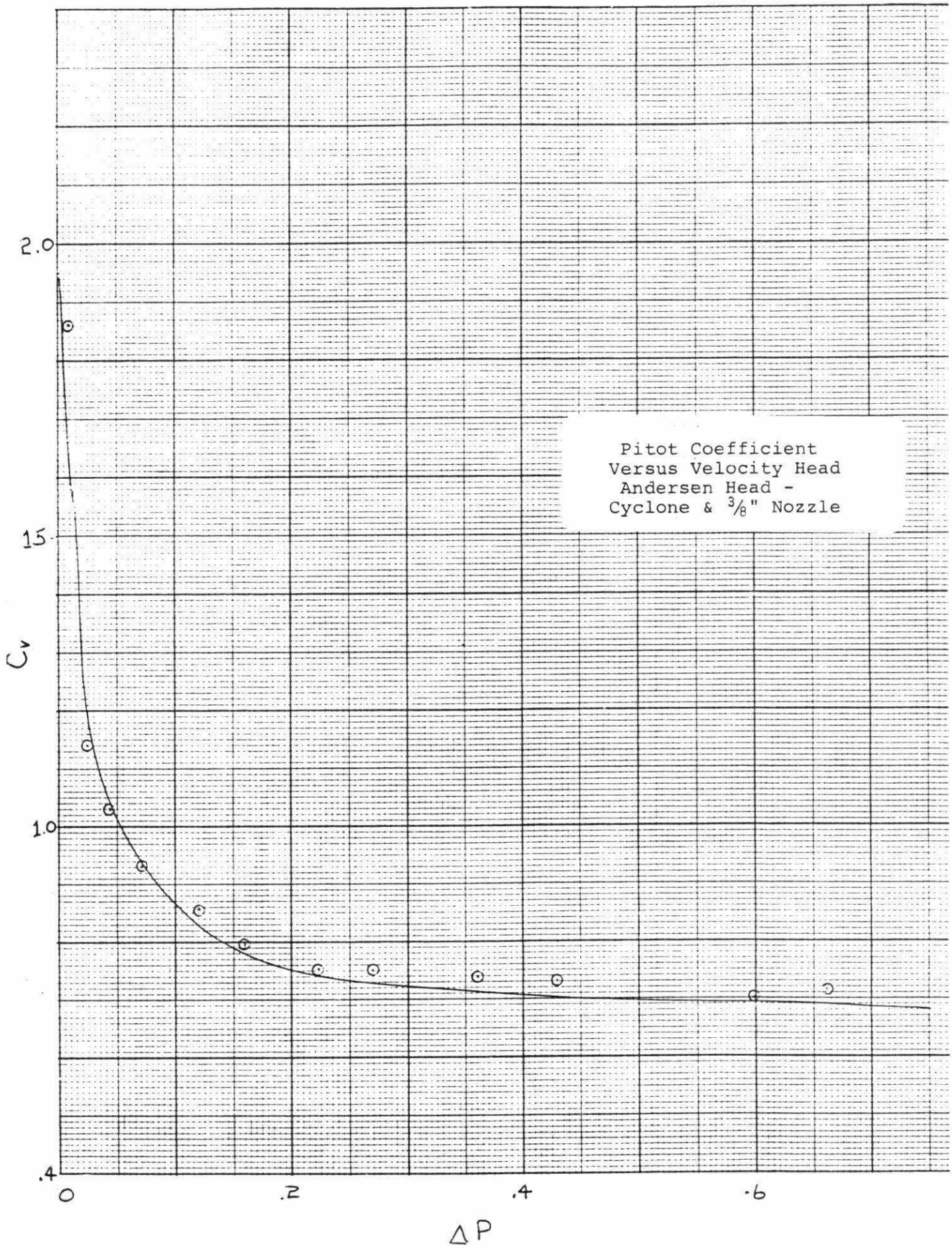
DATE 8/8/79 AMBIENT TEMPERATURE 25°C

INSTRUMENT Andersen Head Cyclone & 3/8" nozzle REFERENCE STANDARD .99 st'd Pitot Tube

BAROMETRIC PRESSURE 75.49 cm Hg

(Where necessary, illustrate orientation of probe components on other side of page.)

Wind Tunnel Fan Speed (RPM)	m/s	Temperature Wet	Temperature Dry	Δ P Ref. cm(x.2)	Δ P Instrument/Velocity Reading cm x.2	inches	C_v
50	3.36	20	26	.35	.05	.004	2.62
150	3.36			.35	.1	.008	1.85
250	3.59			.4	.3	.024	1.14
350	4.4			.6	.55	.043	1.03
450	5.08			.8	.9	.071	.933
575	5.82			1.05	1.5	.118	.828
650	6.47			1.3	2	.157	.798
750	7.19			1.6	2.75	.217	.755
860	8.03			2.0	3.45	.272	.754
1000	9.16			2.6	4.6	.362	.744
1060	9.84			3.0	5.45	.429	.734
1210	11.07			3.8	7.6	.598	.700
1300	11.92			4.4	8.4	.661	.717
1400	13.02			5.25	9.8	.772	.725
1510	14.26			6.3	11.8	.929	.723
1650	15.51			7.45	14.2	1.118	.717
1700	16.28	21	25	8.2	15.5	1.22	.720


Pitot Coefficient
Versus Velocity Head
Andersen Head -
Cyclone & 3/8" Nozzle
2.0
1.5
1.0
.4
Cv
0
.2
.4
.6
ΔP

TD
883.7
.O6
O9
1982